Metcalf & Eddy
An Air & Water Technologies Company

May 30, 1997

Ms. Diane Spencer, Project Coordinator
U.S. Environmental Protection Agency, Region 5
Office of Superfund, Remedial & Enforcement Response Branch
77 West Jackson Boulevard
Chicago, Illinois 60604-3590

Subject: **Granville Solvents Site Removal Action**
Revised EE/CA Section 2.5 Streamlined Risk Evaluation

Dear Ms. Spencer:

As promised in our last correspondence on May 23, 1997, we are providing you with revised Section 2.5 Streamlined Evaluation for the Engineering Evaluation/ Cost Analysis for the Treatment of Impacted Soil dated March, 1997. This revised section has been revised to incorporate additional exposure scenarios not presented in the document as discussed in our meeting May 19, 1997. Information presented in other reports is more fully included in this section so that the document provides a more complete history of site conditions and previous work completed. The will allow this document to stand alone without requiring the reader to search for information outside of the document.

Because the page numbers have changed, we are providing the Section 2.5 and all subsequent sections, including tables and figures. In addition, we have updated the table of contents to reflect these changes. Please replace the originals pages with these revised pages.

If you have questions, please contact Michael Raimonde or me at (614) 890-5501.

Respectfully,

METCALF & EDDY OF OHIO, INC.

Michael J. Raimonde for

Gerald R. Myers
Vice President/Project Coordinator

Attachments

cc: B. Pfefferle, TH&F
M. Anastasio, U.S. EPA
F. Myers, OEPA
J. Hickman, Village of Granville
M. Raimonde, M&E

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Pumping Report). Results, so far, show the extraction rates (160 gal/min from EW-1, and 75 gal/min from EW-2) are effective in maintaining the barrier and removing the contaminants. Both wells are highly efficient and could be pumped at much higher rates if needed. The pumping tests showed this aquifer to be extensive and highly transmissive. Although the supply wells require cleaning and iron removal from time to time, water levels in the aquifer recover quickly when the wells are shut down and there is no evidence of over-pumping.

2.4 ANALYTICAL DATA

2.4.1 Groundwater Data

The groundwater data collected during the course of the Removal Action are summarized above. The data collected by the PRP Group are included for reference in Appendix A.

2.4.2 Soil Data

The soil data collected during the course of the Removal Action are summarized above. The data collected by the PRP Group are included for reference in Appendix A.

2.5 STREAMLINED RISK EVALUATION

2.5.1 Introduction to the Risk Evaluation

A streamlined risk evaluation was performed for the chemicals remaining in soil at the GSS. The potential for adverse health effects to occur in association with exposure to these chemicals was determined for two groups of receptors most likely to come into contact with the soil at the site, namely, excavation workers and industrial workers. The results of the risk evaluation for an excavation worker and an industrial worker demonstrate that the risks associated with exposure to soil is below or within the U.S. EPA target range of 1E-04 to 1E-06 for carcinogenic risk and below the target noncancer hazard index of 1. The U.S. EPA has set risks on the order of 1E-04 to 1E-06 as the target range for risks at Superfund Sites (U.S. EPA, 1991). According to OSWER Directive 9355.0-30 (April 22, 1991), the total site risk to an individual should not exceed 1E-04 for lifetime excess cancer risk (U.S. EPA, 1991). For the excavation worker, exposure to soil via incidental ingestion, dermal contact with, and inhalation of volatile organic chemicals was associated with a total carcinogenic risk of 4E-08 and a cumulative noncancer hazard index of 0.0014. For the industrial worker, the total carcinogenic risk and noncancer hazard index associated with exposure to soil via incidental ingestion, dermal contact with, and inhalation of volatile organic chemicals was 5E-06 and 0.043, respectively, which is only slightly higher than the excavation risk, but well within the U.S. EPA risk levels.

The streamlined risk evaluation was conducted only for the soils at the GSS. Site data collected in accordance with the *Design Technical Memorandum* (1995), *Groundwater Monitoring Program Plan* (1995), and the *Quality Assurance Project Plan* (1995) which were subsequently reported in the *Soil Data Summary Report* (1996) and the *Groundwater Monitoring Well Installation Report* (1996), were used in this risk evaluation. These data have been summarized in Sections 2.3 and 2.4 of this EE/CA. Chemicals of concern were identified first in the *Design Technical Memorandum* and again below, based on previous investigations. The streamlined risk evaluation provides an estimate of how, and to what extent, people might be exposed to the chemicals of concern and assesses the potential health effects if no action is taken on the Site soils at the GSS.

The AOC orders the PRP Group to:

> *"Treat soils at the Site to levels which will assure protection of human health and the environment, to levels which will attain all risk-based standards and federal and state ARARs, and to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels."* (Section V.2.g).

This section of the report is separated into seven parts including this introduction. The conceptual site model of this property and the land use scenarios and potential pathways for exposure based on future use are described in Section 2.5.2. The chemicals of concern are identified and discussed in Section 2.5.3. Based on these chemicals and the potential exposure pathways, chemical exposure modeling was conducted and the results discussed in Section 2.5.4. The potential exposures to the chemicals of concern are evaluated using U.S. EPA risk assessment methodology. The risk characterization is provided in Section 2.5.5. As a means to evaluate the effect that the Site soils will have on the groundwater beneath the Site, the PRP Group developed a groundwater flow and contaminant fate and transport model. This model and its results were provided to the U.S.EPA in the *Groundwater Flow and Contaminant Fate and*

Transport Report (1996) and summarized below in Section 2.5.6. Section 2.5.7 is a summary of the streamlined risk evaluation and establishes treatment goals for the Site soils.

2.5.2 Conceptual Site Model

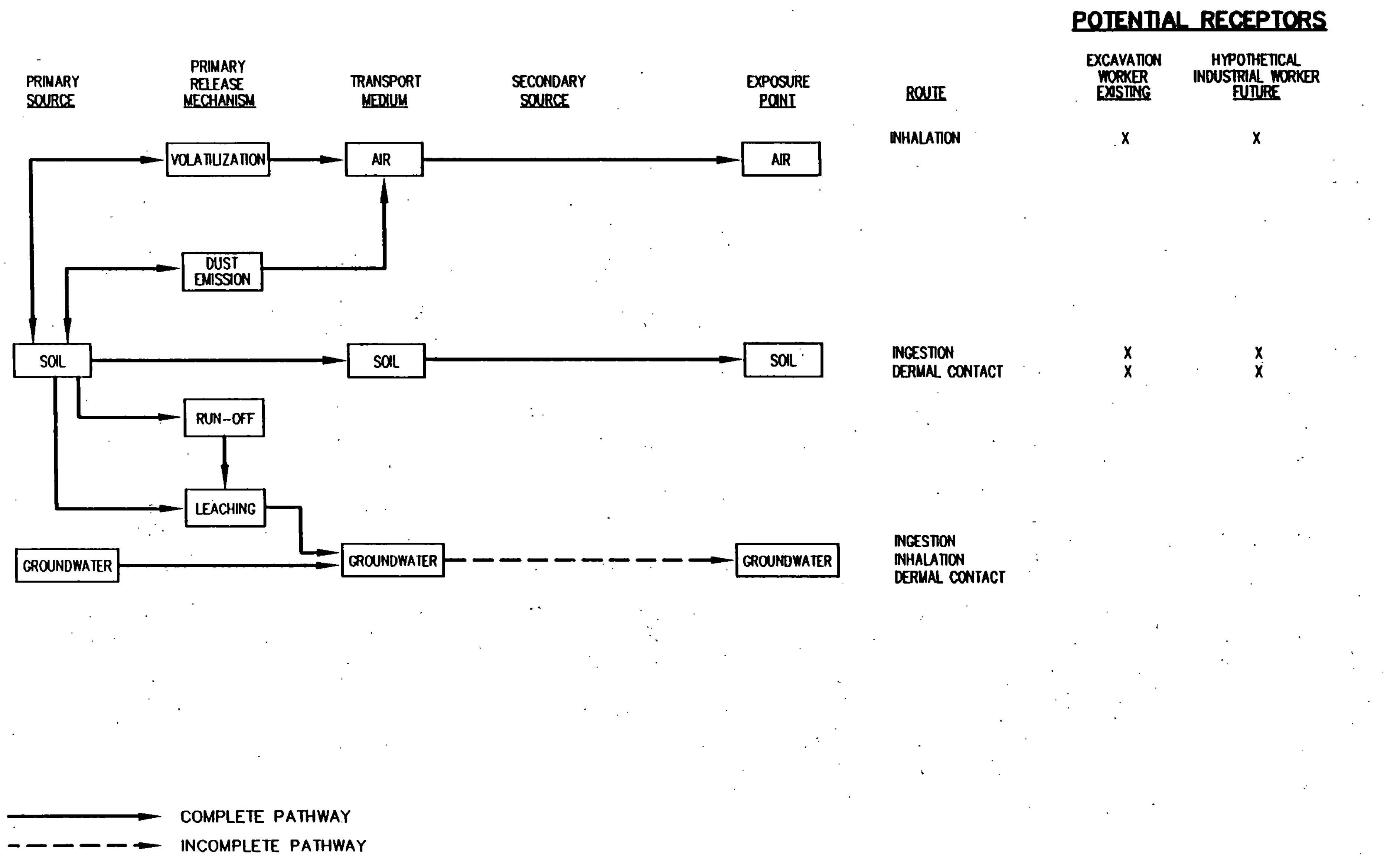
The conceptual site model (CSM), shown in Figure 17, was developed to present an understanding of the site dynamics for use in the exposure assessment of the risk evaluation. The CSM also delineates important fate and transport processes. In general, the CSM provides a presentation of the matrix of potential chemical sources and migration pathways, routes of exposure, and receptors potentially subject to exposure to chemicals in the environmental media at the GSS. The CSM focuses on complete exposure pathways. For an exposure pathway to be complete the following components must all be present: a source, a release mechanism, a transport medium, an exposure point, and a receptor.

Exposure pathways describe the movement of chemicals from sources to media where exposed populations (receptors) could potentially come in contact with the chemicals. Exposure routes describe the modes of contact and intake of chemicals in environmental media at exposure points. For example, trichloroethene in the soil (the source) at the GSS could be encountered or uncovered during drilling or excavation activities and released as a vapor (through a volatilization release mechanism) into the air (the transport medium). The air containing the trichloroethene could then be breathed by the excavator (through inhalation at the exposure point). This is a hypothetical scenario and such exposure pathways would be prevented through Health and Safety Practices enforced at the site. However, the example is illustrative of how the CSM is developed to characterize how exposures or contact with site-related chemicals might occur.

The human populations, individuals, or receptors who could feasibly be exposed to chemicals from the site are key to the process of characterizing risk associated with the site. The potential land use scenarios and receptors of concern for the GSS are presented in the following section.

2.5.2.1 Land Use Scenarios and Potential Populations of Concern

The Granville Solvents Inc. property located at 300 Palmer Lane in Granville, Licking County, Ohio operated as a petroleum bulk storage, distribution, and recycling facility and later as a solvent recycling and reclamation facility at this location for over 30 years. This long history of industrial use for this



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GRANVILLE SOLVENTS
HUMAN HEALTH SITE CONCEPTUAL MODEL
GRANVILLE, OHIO

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property is well established and it is still owned by Granville Solvents, Inc. At the present time, a locked twelve-foot high fence with three-strand barbed wire has been placed around the Site and area of impacted soil as ordered by the AOC (*Site Security Plan*, M&E, 1994). Based on the previous use and potential future use of the property, there are only two likely receptor groups who could feasibly be exposed to chemicals from the site for an extended period of time. The potential receptors of concern for the GSS site are excavation workers and industrial workers.

Even though the site is under secure conditions, there is the potential that there will be a time when it may be necessary to cross this Site with an underground utility, such as a sewer or electric line. In such a case, an excavation worker may be required to excavate soil to a given depth and install equipment below grade. There is the potential that this worker will be exposed for a short duration to the chemicals present in the Site soils via incidental ingestion, dermal contact, and inhalation of volatile emissions. Under no other conceivable circumstances could a person or persons realistically be exposed to subsurface soils at the site governed by current or future Site control.

The existing conditions of the site are expected to remain as is, enclosed by a locked fence and void of any long-term land use activity (i.e., residential use, commercial use, etc.). The area has limited space available for redevelopment. The presence of the water treatment plant and bridge overpass will most likely prevent any type of development of the site. However, the site is located on land that has been zoned for industrial use, and is bounded on the east and west by industrial property and on the south by a no-build zone adjacent to Raccoon Creek. Future plans to rezone the area do not currently exist, and zoning for industrial use will continue into the future. Therefore, the potential for an on-site future industrial worker does exist, however, exposure to chemicals of concern located eight to ten feet below surface is highly unlikely to occur.

Nevertheless, an industrial receptor will be included as a potential receptor for the GSS albeit a highly unlikely one, assuming redevelopment of the site for industrial use would bring soils at depth to the surface where potential exposure could occur via incidental ingestion, dermal contact, and inhalation of volatile emissions.

2.5.2.2 Exposure Assumptions for the Potential Receptors

For the excavation worker, the on-site work activities are assumed to occur 30 days per year, during which time the worker is on-site for eight hours per day. The excavation worker is also assumed to have a daily ingestion rate of 480 mg/kg. In addition, it is assumed that dermal exposure occurs at the head, hands, and arms, so that the skin surface area exposed is 3,200 cm^2. An adherence factor of 1.0 is used in conjunction with a default skin absorption factor of 25 percent. Furthermore, it is assumed that the excavation worker would not be physically handling the soil but would rely on bulldozers or backhoes, so that the inhalation rate of 0.83 m^3/hr for moderate activity is appropriately utilized for the inhalation exposure. For non-carcinogenic effects, exposure is averaged over the product of the exposure duration (in years) times 365 days per year. The exposure duration is the period of time over which the event may occur. Therefore, an exposure duration of one year is assumed for evaluating noncarcinogenic effects of the excavation worker. The length of time that the excavation worker may be in contact with soils is considered to be a short term, or subchronic exposure as opposed to a long-term, or chronic (greater than 7 years) exposure.

For the industrial worker, the on-site work activities are assumed to occur 250 days per year, during which time the worker is on-site for eight hours per day. The industrial worker is assumed to have a daily ingestion rate of 100 mg/kg. In addition, it is assumed that dermal exposure occurs at the head, hands, and arms, so that the skin surface area exposed is 3,200 cm^2. An adherence factor of 1.0 is used in conjunction with a default skin absorption factor of 25 percent. The inhalation rate of 0.83 m^3/hr for moderate activity is appropriately utilized for the inhalation exposure. For non-carcinogenic effects, exposure is averaged over the product of the exposure duration (in years) times 365 days per year. The exposure duration of 25 years is assumed for evaluating noncarcinogenic effects of the industrial worker. The length of time that the excavation worker may be in contact with soils is considered to be a long-term, or chronic (greater than 7 years) exposure.

2.5.3 Chemicals of Potential Concern for the Soil Removal Action

Previous investigations identified the compounds in Tables 2-2 and 2-9. Chemicals of potential concern were identified and reported in the December 8, 1995, *Design Technical Memorandum* (1995). The chemicals of concern were identified based on the general types of chemicals described in the Administrative Order on Consent and the analytical results of historical sampling of groundwater and soil.

These chemicals of concern were limited to 22 volatile organic compounds which had been detected in soil and/or groundwater.

Consistent with the sampling plan specified in the *Design Technical Memorandum*, soil samples were collected and analyzed for VOCs, SVOCs, and RCRA metals. Results were reported in the *Soil Data Report* (1996) and are summarized in Sections 2.3 and 2.4 of this report. Three SVOCs were detected, two in one sample (SB-5, fluoranthene and pyrene), and one in SB-26 (diethylphthalate). These compounds occurred only in these locations and are of no direct consequence to this risk evaluation.

For the purposes of this streamlined risk evaluation, chemicals of concern for inclusion in the risk evaluation were selected based on the criterion of a single occurrence of a VOC above detection limits in the soil sampling results of the April 1996 soil sampling event. The chemicals of concern are listed in Table 2-9.

TABLE 2-9
CHEMICALS OF CONCERN FOR THE GRANVILLE SOLVENTS SITE

1,1,1-Trichloroethane	Carbon disulfide
1,1,2-Trichloroethane	Chlorobenzene
1,1-Dichloroethane	Chloroform
1,1-Dichloroethene	Ethylbenzene
1,2-Dichloroethene (cis)	Methylene chloride
1.2-Dichloroethene (trans)	Tetrachloroethene
1,2-Dichloroethene (mixture)	Toluene
2-Butanone	Trichloroethene
Acetone	Vinyl chloride
Benzene	Xylenes

2.5.4 Chemical Exposure Modeling

The chemical exposure concentration is the concentration of a chemical in soil that will be contacted by a receptor. The exposure concentration typically utilizes an average of the concentration that could be contacted over an exposure period. However, to provide a conservative approach of estimating exposures in this streamlined risk evaluation, exposure concentrations are based on the maximum concentration of each parameter detected in soil. The use of maximum values as the exposure point assumes that concentrations will remain constant over the duration of exposure (i.e., up to 70 years). This assumption is conservative, given environmental fate processes such as dilution, attenuation, and biodegradation which would be expected to cause concentrations to decrease over time. Constituent concentrations may remain constant or decrease, but it is unlikely that they will increase.

Ambient air concentrations were also derived from maximum soil concentrations of the components based on the predictive modeling techniques of Baker and MacKay (1985, U.S. EPA, 1989), U.S. EPA Superfund Exposure Assessment Manual (U.S. EPA 1988), and Gifford & Hanna (1970), and Tennekes (1976). Given that the maximum concentrations detected were generally from samples collected below a depth of six feet, these ambient air concentrations are, again, conservative. Again, it should be noted that estimates of exposure concentrations in ambient air are modeled from soil assuming that concentrations will remain constant over the duration of exposure. As stated previously, this assumption is conservative, given that environmental fate processes such as dilution, attenuation, hydrolysis, volatilization, and biodegradation are expected to cause concentrations to decrease over time. The constituent concentrations utilized in the exposure evaluation are presented in Table 2-10. These concentrations represent the maximum concentrations detected in the entire depth of soils which were evaluated.

2.5.5 Risk Characterization

The risk characterization serves to provide a comparison of the exposure concentrations estimated and applicable toxicological or dose-response data developed for the chemicals of concern. The outcome of this comparison is used to determine whether the chemical concentrations detected in soil at GSS may be associated with adverse effects on the health of excavation workers and hypothetical future industrial workers potentially exposed to site-related chemicals. Adverse health effects are defined as carcinogenic risk (i.e., cancer) or noncarcinogenic hazard (i.e., kidney disease).

Information relevant to the carcinogenic and/or noncarcinogenic potential of the chemicals of concern is derived from laboratory research studies. U.S. EPA evaluates chemical-specific toxicity data to derive appropriate toxicity criteria or guidelines for the protection of human health. Carcinogenic and

TABLE 2-10
SUMMARY OF EXPOSURE CONCENTRATIONS

	Soil Maximum Concentration (a) (mg/kg)	Modeled Ambient Air Concentration (b) (mg/m^3)
1,1,1-trichloroethane	1.7	0.00426
1,1,2-Trichloroethane	0.012	0.000006
1,1-Dichloroethane	0.011	0.00013
1,1-Dichloroethene	0.007	0.00009
1,2-Dichloroethene (cis)	4.6	0.03
1,2-Dichloroethene (trans)	0.021	0.00014
1,2-Dichloroethene (total)	4.8	0.02
2-Butanone	0.014	2E-9
acetone	0.084	4E-8
benzene	0.014	2E-9
carbon disulfide	0.7	4E-7
chlorobenzene	0.027	5E-10
chloroform	0.002	1E-9
ethylbenzene	3.6	6E-8
methylene chloride	0.002	2E-9
tetrachloroethene	18	7E-7
toluene	0.34	2E-8
trichloroethene	11	2e-6
vinyl chloride	0.03	1E-7
xylenes (total)	44	7E-7

(a) Maximum soil concentrations based on analytical results provided in the Soil Data Report (M&E, December 20, 1996).

(b) Ambient air concentrations based on predictive techniques of Baker and MacKay (1985. U.S. EPA, 1989), U.S. EPA Superfund Exposure Assessment Manual (U.S. EPA 1988), and Gifford & Hanna (1970), and Tennekes (1976).

noncarcinogenic toxicity factors which have been derived for the chemicals of concern are provided in Table 2-11. Noncarcinogenic toxicity values are referred to as reference doses (RfD). Reference doses are levels of chemicals which are expected to be without adverse health consequences based on daily intake by a specified route of exposure. Carcinogenic toxicity values are referred to as cancer slope factors (CSF). The slope factor is an upper bound estimate of the dose-response curve for developing cancer per dose of chemical.

This risk characterization estimates the carcinogenic risks and the noncarcinogenic hazards which may be associated with the doses of chemicals experienced by an excavation worker and a hypothetical future on-site industrial worker.

Excavation Worker

The excavation worker is assumed to be involved in trenching activities on the GSS property for installation of some type of utility line, such as a sewer. Subsurface soils (greater than 4 feet) may be brought to the surface during digging and excavating for building foundations or utilities. Therefore, the excavation worker is assumed to have potential exposure to the full soil column (0 to 20 feet). However, the excavation worker is not likely to have extensive direct contact with soils, but would rely on the use of heavy machinery such as backhoes.

Industrial Worker

The hypothetical future industrial worker is assumed to have potential exposure to the full soil column also if excavated soils from redevelopment of the site are brought to the surface and used for regrading or landscaping of the site.

2.5.5.1 Evaluation of Non-Carcinogenic Hazards

The potential noncarcinogenic hazards were assessed quantitatively by evaluating exposure estimates with respect to available toxicity values (Table 2-11) for the chemicals of concern.

The potential for adverse noncarcinogenic effects from chemical exposure is expressed in terms of the hazard quotient (HQ). The hazard quotient is the ratio of the estimated dose, or exposure, which a human receives to the estimated dose level believed to be safe, the reference dose (RfD).

TABLE 2-11 TOXICITY VALUES FOR CHEMICALS OF POTENTIAL CONCERN AT GSS

CHEMICAL	TOXICITY INFORMATION* NONCARCINOGENIC RfDs ORAL RfD (mg/kg/day) SUBCHRONIC	CHRONIC	ADJUSTED ORAL (DERMAL) RfD (b) (mg/kg/day) SUBCHRONIC	CHRONIC	INHALATION RfD (mg/kg/day) SUBCHRONIC	CHRONIC	CANCER SLOPE FACTORS ORAL SLOPE FACTOR (mg/kg/day)-1	ADJUSTED ORAL (DERMAL) SLOPE FACTOR (a) (mg/kg/day)-1	INHALATION SLOPE FACTOR (mg/kg/day)-1	Oral Absorption Factor (c) (UNITLESS)
1,1,1-Trichloroethane	9.0E-02	NA	NA	NA	2.9E-01	2.9E-01	NA	NA	NA	1.0E+00
1,1,2-Trichloroethane	4.0E-02	4.0E-03	4.0E-02	4.0E-03	NA	NA	5.7E-02	5.7E-02	5.7E-02	1.0E+00
1,1-Dichloroethane	1.0E+00	1.0E-01	1.0E+00	1.0E-01	1.4E+00	1.4E-01	NA	NA	NA	1.0E+00
1,1-Dichloroethene	9.0E-03	9.0E-03	7.2E-03	7.2E-03	NA	NA	6.0E-01	7.5E-01	1.2E+00	8.0E-01
1,2-Dichloroethene (cis)	1.0E-01	1.0E-02	9.0E-02	9.0E-03	NA	NA	NA	NA	NA	9.0E-01
1,2-Dichloroethene (trans)	2.0E-01	2.0E-02	1.8E-01	1.8E-02	NA	NA	NA	NA	NA	9.0E-01
1,2-Dichloroethene (mixture)	9.0E-03	9.0E-03	8.1E-03	8.1E-03	NA	NA	NA	NA	NA	9.0E-01
2-Butanone	2.0E+00	6.0E-01	1.6E+00	4.8E-01	2.9E-01	2.9E-01	NA	NA	NA	8.0E-01
Acetone	1.0E+00	1.0E-01	1.0E+00	1.0E-01	NA	NA	NA	NA	NA	1.0E+00
Benzene	NA	3.0E-04	NA	2.7E-04	1.7E-02	1.7E-03	2.9E-02	3.2E-02	2.9E-02	9.0E-01
Carbon disulfide	1.0E-01	1.0E-01	8.0E-02	8.0E-02	3.0E-03	2.0E-01	NA	NA	NA	8.0E-01
Chlorobenzene	NA	2.0E-02	NA	1.6E-02	NA	5.0E-03	NA	NA	NA	8.0E-01
Chloroform	1.0E-02	1.0E-02	9.5E-03	9.5E-03	NA	NA	6.1E-03	6.4E-03	8.1E-02	9.5E-01
Ethylbenzene	1.0E-01	1.0E-01	8.0E-02	8.0E-02	2.9E-01	2.9E-01	NA	NA	NA	8.0E-01
Methylene chloride	6.0E-02	6.0E-02	4.8E-02	4.8E-02	8.6E-01	8.6E-01	7.5E-03	9.4E-03	1.6E-03	8.0E-01
Tetrachloroethene	1.0E-01	1.0E-02	1.0E-01	1.0E-02	NA	NA	5.2E-02	5.2E-02	2.0E-03	1.0E+00
Toluene	2.0E+00	2.0E-01	2.0E+00	2.0E-01	NA	1.1E-01	NA	NA	NA	1.0E+00
Trichloroethene	NA	6.0E-03	NA	6.0E-03	NA	NA	1.1E-02	1.1E-02	6.0E-03	1.0E+00
Vinyl chloride	NA	NA	NA	NA	NA	NA	1.9E+00	2.4E+00	3.0E-01	8.0E-01
Xylenes	NA	2.0E+00	NA	1.8E+00	NA	8.6E-02	NA	NA	NA	9.0E-01

NA - Toxicity values (RfD/CSF) not available from IRIS, HEAST, scientific literature, USEPA nor OhioEPA for risk evaluation.
H - Health Effects Assessment Summary Tables (HEAST)
I - Integrated Risk Information Service (IRIS)
N - National Center for Environmental Assessment (NCEA)
Sources: U.S. EPA, Integrated Risk Information System (IRIS) database accessed January 1996.
U.S. EPA Health Effects Assessment Tables (HEAST), Annual FY-1995 edition(Heast, 1995).
Note: Region IV default oral absorption factors were used when necessary and are as follows: VOCs - 0.80, SVOCs - 0.50, inorganics - 0.20.
(a) Adjusted oral toxicity values used for calculation of dermal risks.
Adjustment of an administered to an absorbed dose CSF: (Administered CSF)-1/(Oral Absorption Factor) = Absorbed Dose CSF
(b) Adjusted oral toxicity values used for calculation of dermal hazards.
Adjustment of an administered to an absorbed dose RfD: (Administered RfD) x (Oral Absorption Factor) = Absorbed Dost RfD
(c) Oral absorption factors from chemical-specific Toxicological Profiles, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service.

The hazard quotient is calculated as follows:

$$HQ = DI/RfD \tag{1}$$

Where:

HQ	=	Hazard Quotient
DI	=	Daily Intake
RfD	=	Reference Dose

Once the hazard quotients for each chemical in each of the exposure pathways are determined, they are added together to calculate a total site non-cancer hazard index (HI). If the hazard index value is less than 1.0, it is believed the potential of non-carcinogenic injury is low. If the hazard index exceeds 1.0, potential of non-carcinogenic effects may exist.

The hazard quotients calculated for each of the chemicals of potential concern and excavation exposures considered in this streamlined risk evaluation are provided in Appendix A. These hazard quotients were then added together to calculate the total hazard index for the Site. The results of these calculations are summarized in Tables 2-12 and 2-13.

2.5.5.2 Evaluation of Carcinogenic Risks

The increased incidence of cancer from exposure to a chemical is described in terms of the probability that an individual will develop cancer as a result of that exposure. It is assumed that even a single incident of exposure has a life-long effect on the probability of developing cancer. Cancer is a general term for a collection of different diseases, with varying degrees of survivability. This evaluation, however, does not specify the type of cancer (i.e., malignant or benign) that may occur, nor does it specify the target organ or location of cancer that may result.

The probability, or risk value, is calculated by multiplying the average daily intake (DI) by the chemical-specific cancer slope factor (CSF). Because the probability of the incidence of cancer is assumed to occur over a lifetime, even for a single incident of exposure, the exposure is averaged over 70 years (25,550 days) for carcinogenic effects.

TABLE 2-12
SUMMARY OF RISK AND HAZARD CALCULATIONS
HYPOTHETICAL FUTURE ADULT EXCAVATION WORKER

EXPOSURE TO CHEMICALS	EXCAVATION WORKER (SHORT TERM)			
	Matrix	Route	Risk	Hazard
	Soil	Ingestion	9E-09	0.0005
		Dermal	1E-08	0.0008
		Inhalation	1E-08	0.0002
	Total		4E-08	0.0014

TABLE 2-13
SUMMARY OF RISK AND HAZARD CALCULATIONS
HYPOTHETICAL FUTURE ADULT INDUSTRIAL WORKER

EXPOSURE TO CHEMICALS	**INDUSTRIAL WORKER (LONG TERM)**			
	Matrix	Route	Risk	Hazard
	Soil	Ingestion	2E-07	0.002
		Dermal	3E-06	0.04
		Inhalation	2E-06	0.001
	Total		5E-06	0.043

This risk value is calculated by multiplying the average daily intake (DI) by the carcinogenic slope factor for the chemical:

$$Cancer\ Risk = DI \times CSF \tag{2}$$

Risk estimates are presented as cancer risk per unit of population. For example, a risk estimate of 1E-04 is equivalent to one occurrence of cancer per 10,000 individuals in a given population.

The risk estimates calculated for each of the chemicals of potential concern and exposures considered in this risk evaluation are provided in Appendix A. The results of these calculations and the total carcinogenic risk estimate for the site are summarized in Tables 2-12 and 2-13.

2.5.5.3 Results

Excavation Worker

A total Site hazard index and risk estimate was calculated for the excavation worker. The total site noncancer hazard index was 0.001. The total Site cancer risk estimate for the excavation receptor was 4E-8. The findings of the excavation exposure evaluation indicated that the carcinogenic risks associated with maximum concentrations of volatile organic chemicals detected in soil is less than the U.S. EPA risk range of 1E-06 to 1E-04 and the noncancer hazard is less than the hazard criterion of 1. In other words, based upon the methodology utilized, the excavation worker's risk of acquiring any adverse health effects, either carcinogenic or noncarcinogenic, as a result of exposure to concentrations of chemicals evaluated in this streamlined risk evaluation is virtually nonexistent.

Industrial Worker

A total Site hazard index and risk estimate was calculated for the hypothetical future industrial worker. The total site noncancer hazard index was 0.043. The total Site cancer risk estimate for the excavation receptor was 5E-6. The findings of the hypothetical future industrial worker exposure evaluation indicated that the carcinogenic risks associated with maximum concentrations of volatile organic chemicals detected in soil is within the U.S. EPA risk range of 1E-06 to 1E-04 and the noncancer hazard is less than the hazard criterion of 1.XX Again, these risk results indicate that exposure to concentrations of chemicals identified in the soil at the GSS do not result in unacceptable adverse health effects, either carcinogenic or noncarcinogenic, for an industrial worker based upon the methodology utilized in this risk evaluation.

2.5.6 Results of the Fate and Transport Modeling

The results of the risk evaluation for direct contact with soil demonstrate that concentrations of chemicals of concern remaining in soil meet the first objective of the AOC which requires that soil levels assure protection of human health. However, the second objective of the AOC which requires that no groundwater beneath the soils become contaminated above the groundwater no further action levels has not been attained. Therefore, the streamlined risk evaluation shifts from the protection of human health focus to protection of the environment by centering on the fate and transport of chemicals which can potentially migrate from soil to groundwater.

A *Groundwater Flow and Contaminant Fate and Transport Model Report* was submitted to the U.S. EPA on December 20, 1996 and is summarized below.

The primary objective of the modeling project was to provide a means for comparing remedial alternatives. The critical factor in the comparisons involved the interaction between the low permeability surface soils and the aquifer. The soils at the GSS site contain significant concentrations of chlorinated and other compounds that are slowly contributing dissolved phase solvents to the aquifer. Given the need to model the interaction between the soils and the aquifer, a numerical model was chosen. This type of interaction can be effectively handled with a numerical model, but is beyond the capabilities of analytical models.

MODFLOW was chosen as the numerical flow model for this project. MODFLOW is the standard numerical groundwater flow model commonly in use today. It has been thoroughly tested and widely accepted by industry, consultants, and the regulatory community. Visual MODFLOW, a graphical interface for MODFLOW, MODPATH, and MT3D, was used for importing data to the model and graphically portraying the results.

MODPATH was also used for establishing flowpaths within the model and establishing times of advective travel along the flowlines. A program known as MT3D96 was used for contaminant fate and transport modeling. This newly updated fate and transport code incorporates the features of the older versions of MT3D with new options and algorithms to facilitate more complex simulations.

MODEL DESCRIPTION

The procedures used to implement the models and the specific parameters chosen are described in detail in the *Groundwater Flow and Contaminant Fate and Transport Model Report* (December 20, 1986), and is briefly described here.

The procedures used to implement the models and the specific parameters chosen for the initial set-up of the model are described.

The model grid encompasses an area of approximately 2 square miles surrounding the GSS. The area away from the pumping centers was gridded in 250 feet cells. Within the pumping centers the grid was refined to cells with width and length of 50 feet.

The model was divided vertically into 10 layers. The upper five layers depict the clay rich soil overlying the aquifer and were given identical input parameters due to the relative homogeneity of the soils (determined based on the results of the soil sampling program at the site). The reason for dividing the clay soil into separate layers was to provide a higher level of resolution for soil contaminant concentrations within the soil column. The lower five layers of the model represent the soil and gravel of the buried valley aquifer.

Two types of aquifer boundary conditions, no-flow and constant head, were used in modeling the aquifer system. No-flow boundaries were used at the bedrock walls of the buried valley system. The bedrock is composed of the Raccoon Shale, which is of very low permeability, compared to the highly permeable sand and gravel of the buried valley aquifer. For this reason, it was appropriate to designate the bedrock walls as no-flow boundaries in the model.

The location of the bedrock walls was based on area topography, a bedrock surface map, oil and gas exploration borings, and the experience of M&E staff geologists with this buried valley system. The floor of the main bedrock valley was also modeled as a no-flow boundary. Depth to the bedrock floor in the modeled region was established based on the bedrock map, available oil and gas exploration boring logs, and borings completed as a part of the investigations at the GSS and the Granville wellfield. The bedrock surface was entered into the model as the bottom of model layer 10.

Constant head flow boundaries were arbitrarily established transverse to the main buried valley above and below the modeled area. This allowed flow into and out of the area through the aquifer. No information was available regarding the downvalley regional gradient in the buried valley beyond the pumping influence. The direction of flow of Raccoon Creek is from west to east, and it can be presumed that the regional gradient would also be to the east. However, in keeping with the decision to provide assumptions that increase the probability of the model predicting impact to the wellfield, constant head flow boundaries at the same elevation were chosen for the east and west boundaries of the valley. Under background (non-pumping) conditions, these levels would have resulted in no gradient either up or down the valley. Any background gradient in this system would probably be from west to east and tend to lessen the influence of the Granville wells on the groundwater flow at the GSS. The constant head flow boundaries are far enough from the pumping centers to have only minimal influence on model results.

Raccoon Creek flows through the central portion of the valley in most of the modeled area. The creek turns northward near the GSS and flows eastward in a course that lies just south of the site. This represents the closest approach of the creek to the site and the northern boundary of the buried valley system within the modeled area.

Raccoon Creek was not included in the model. The choice not to include the creek was based on information obtained from pumping tests which indicated that the creek does not interact significantly with the aquifer under pumping conditions (*Aquifer Pumping Test Report*, 1995). If interaction were present between the creek and the aquifer, the creek would be a losing stream through the modeled area based on relative water levels. Water added to the aquifer from the stream would tend to diminish the effects of the Granville wells on the aquifer beneath the GSS. Thus, excluding the creek from consideration in the model increased the probability of the model predicting impact to the wellfield from the GSS.

No-flow boundaries were used on all horizontal edges of layers comprising the clay-rich upper soils. Given the low permeability of these soils, the choice of boundary conditions in a regional model is insignificant. Constant head cells were also used vertically as the top layer of the clay soils to provide a stable means of introducing recharge to the system. The use of a constant head boundary to represent recharge is discussed in detail below.

Wells for the Village of Granville were placed in the model at their appropriate locations within the modeled area and screened at the appropriate depths within the aquifer. The pumping rates for the wells for calibration runs were based on the rates reported for the 98 hour GSS pumping test. For model prediction runs, the overall pumping rate of the wellfield was distributed between the three supply wells according to their respective productive capacities (i.e., well PW-3 accounted for less production than wells PW-2 and PW-4). In practice, the wells are alternated and each well is pumped at a rate significantly exceeding Village demands. Pumping is therefore intermittent throughout the course of a given day. For the model, however, each well was assumed to pump at a constant rate, and the total pumping rate for the combined wells was matched to their average pumping rate. In keeping with the desire to remain conservative in the model set-up, the total pumping rate was assumed to be twice the current pumping rate for model predictions. The duration of the model runs was typically 30 years into the future. It was assumed that production of the wellfield would remain within a factor of two of the current average pumping rate throughout this 30 year period.

Recharge could not be stably implemented through the use of the MODFLOW recharge package because of the low permeability of the upper clay soil. However, the upper clay soil is known to be saturated from a few feet below the surface to the interface with the aquifer, based on soil moisture values obtained from Shelby tube samples collected during the soil investigation. Given this condition, a consistent gradient will be present through the clay soils to the aquifer interface. This condition was approximated using constant head boundaries at the surface which represent the "water table" within the clay soil. Recharge is largely independent of rainfall conditions. Rainfall in excess of the very low infiltration rate of the soils simply runs off the surface. The clay soil slowly transmits water between a constant head source at the level of saturation and a variable head sink at the interface with the aquifer.

Groundwater flow through the clay soils to the aquifer carries contaminants from the soils to the aquifer. Therefore, the proper representation of flow in the clay soils is essential for making valid predictions regarding how the soils interact with groundwater and bring new contaminants to the groundwater system. The subject of flow through the clay soils is addressed thoroughly in the sensitivity analysis of this model and in model runs comparing the remedial alternatives.

The transmissivity of the aquifer was established from pumping tests at the GSS using observation wells within the GSS and portions of the Granville wellfield. The transmissivity values were input into the model in terms of hydraulic conductivity values for each model layer within the aquifer. Based on boring logs at the GSS and the Granville wellfield, the lower portion is the most permeable part of the aquifer. Therefore, for the initial model set-up, the hydraulic conductivity of the lower two model layers was set higher than the conductivity of the upper three aquifer layers. The conductivities were chosen such that the combined transmissivity of the model layers matched the results of the pumping tests.

The hydraulic conductivity of the overlying clay soil layers was based on laboratory permeability tests of Shelby tube samples collected in the most recent soil sampling program. Twelve laboratory permeability tests were conducted. The hydraulic conductivity determined by these tests ranged from 1×10^{-8} to 9×10^{-8} cm/sec. However, it is not uncommon for laboratory permeability tests to underestimate the conductivity of a clay soil, and it is likely that the true permeability of these soils is somewhat higher than that shown by the tests. Thus, for the initial model the conductivity of the clay soil layers was set at 1×10^{-7} cm/sec.

As discussed above, the vertical flow of water through the clay soil layers is a critical factor in determining the results of the model. A degree of uncertainty in the hydraulic conductivity of these layers is inherent due to the difficulty involved in obtaining reliable conductivity values for low permeability soils. The conductivity value presented above was an appropriate value to enter as an initial estimate and represents the best data available. However. a wide range of conductivity values for the clay soils was evaluated as a part of the sensitivity analysis and a similarly wide range of values was taken to the final stage of the model where the alternatives were compared. As a result, the initial estimate of conductivity for the clay soils is of little consequence. Ultimately, the clay soils were treated in such a way as to maintain a high level of uncertainty in their rates of conductance and still provide meaningful comparisons of the alternatives.

For the layers representing the aquifer, the initial storativity and specific yield values were estimated from the GSS pumping test analyses. A 30 percent porosity was assumed, consistent with textbook values typically given for this type of aquifer.

For the clay layers, estimated values of porosity, storativity, and specific yield were used. The porosity of clay rich soils was estimated at 35 percent. The storativity was assumed to be 0.001 and the specific yield as 0.01 percent. No reliable field method exists for determining storativity in low permeability soils. The specific yield used may appear relatively small in comparison to typical specific yield values for permeable soils. However, little water drains from low permeability clay-rich soils after they reach field capacity (the water holding capacity following gravity drainage). Water enters these surficial soils in response to rainfall, and is removed largely by evapotranspiration during the growing season. The transition between full saturation and field capacity represents the loss of only a very small amount of water in these soils, which is reflected by the low specific yield used in the model.

The soil and groundwater contaminant chosen for analysis in the MT3D model was trichloroethylene (TCE). The choice of this compound was consistent with providing the "worst case" comparison. Several contaminant compounds have been identified in field investigations at the GSS. These compounds include: trichloroethylene, tetrachloroethylene, 1,1,1-trichloroethane, trans-1,2-dichloroethylene, cis-1,2-dichloroethylene, 1,1-dichloroethylene, 1,1-dichloroethane, methylene chloride, chloroform, vinyl chloride, carbon disulfide, acetone, 2-butanone, r-methyl-2-pentanone, ethylbenzene, toluene, and xylene. Distribution of these contaminants in the aquifer and the overlying soils has been investigated and reported in the *Soil Data Report* (1996), and summarized earlier in this report.

TCE is the most highly concentrated and wide-spread compound in both the soil and groundwater at the GSS. It has a low permissible Maximum Contaminant Level (MCL) of 5 μg/L. Tetrachloroethylene (PCE) also has a MCL of 5 μg/L; however, the PCE is lower in concentration than TCE in both soils and groundwater, and PCE is retarded to a greater extent in the soils than is TCE. Based on this information, TCE represents the "worst case" compound for potential impact to the Village of Granville wellfield.

The initial concentrations of TCE assigned to the aquifer layers of the model were based on the concentrations analyzed at the GSS in the Hydropunch® study. This study was completed in 1994 and probably does not represent current concentrations after operation of the pump and treat remediation system for nearly two years. The GSS monitoring wells have shown a decline in TCE concentrations since pumping was started. However, the most complete analysis of the distribution of TCE in the aquifer was from the Hydropunch® study, and to increase the probability of the model predicting wellfield impact, these values were used in the model.

The TCE concentrations assigned to the clay soil layers of the model were based on a soil investigation in the Spring of 1996. Results of this investigation are reported elsewhere in this report. The sample depths in each boring were extrapolated to the level of the model layers. Where soil samples had not been taken directly at the elevation of a model layer, the samples taken above and below the given elevation were examined and the higher concentration of the two was used. The sample locations for each layer were plotted on a map and contoured to provide a concentration distribution for each layer, which was digitized and imported into the model. The closely spaced sampling points were extrapolated to the model grid with the overall concentration of TCE being conserved.

The boring program at the GSS involved a relatively close spacing of boring locations, and specialized techniques were used to detect DNAPLs. DNAPL was not detected. Moreover, the concentrations of solvents in the soils were low enough that DNAPLs are not expected to be present. Therefore, potential effects of DNAPL were not incorporated into the model.

However, it is rarely possible to conclude with certainty that DNAPLs are not present in a soil subject to free phase releases. While the potential presence of DNAPL was not directly analyzed by the model, it was considered qualitatively with respect to the scenarios presented below.

The adsorption and retardation of TCE by organic carbon in the soils was addressed in the model through the use of linear isotherms. The sorption constant for the clay-rich soils was input as 0.0428 ft^3/kg, and the bulk density of the soils was input as 58.2 kg/ft^3. The value for bulk density was based on an average of 12 samples collected in the soil sampling program. The sorption constant is a calculated constant, based on the organic content of the soil and the distribution coefficient of the contaminant. The average organic carbon content of the clay soils was 0.8 percent based on 21 samples from the soil boring program. The octanol/water partition coefficient for TCE is 152 mL/g. The sorption constant was then calculated from these data and entered into the model.

The sorption constant used for the aquifer soils was 0.00268 ft^3/kg. This sorption constant was calculated using an assumed bulk density of 56.5 kg/ft^3 and an assumed carbon content of 0.05 percent. The difference between the sorption constant for the aquifer soils and the clay-rich soils is due to the lower organic carbon content of the aquifer soils. The assumed organic carbon content of the aquifer (0.05 percent) is consistent for this type of aquifer soil. The effect of varying this assumed value is addressed in the sensitivity analysis. Bulk density varies within a relatively narrow range and its variability has little effect on model outcome.

TCE does not degrade abiotically to any great extent. Some abiotic degradation has been cited in the literature, but these values have been called into question by more recent studies. It is now generally accepted that the abiotic degradation of TCE is slow enough to be neglected.

Biological degradation of TCE has been frequently reported. Such degradation occurs in conjunction with biological degradation of other hydrocarbons or under anaerobic conditions. Evidence of biological degradation is present at the GSS. Cis-1,2-dichloroethane (cis-1,2-DCA) is present in the aquifer near EW-1. Small concentrations of this compound were present during the initial studies and the concentrations have increased over time. Cis-1,2-DCA is only produced biologically from degradation of more highly chlorinated compounds.

Although clear evidence of biological degradation is available, there is no way to reasonably quantify the degradation rate. A small degradation constant could have been justified for the model given the site evidence. However, the assumption of no degradation was entered into the model to increase the probability of the model predicting impact to the Granville wellfield.

Reliable values of dispersion and diffusion are rarely available for input to a fate and transport model. Occasionally the values can be backed out of fate and transport calibration procedures when a great deal is known about the nature, timing, and duration of a chemical release. For this site, this level of detail about releases was not available. An assumed value of 10 feet was used for longitudinal dispersivity. The transverse dispersivity was assumed to be ten percent of the longitudinal dispersivity and the vertical dispersivity was assumed to be 1 percent of the longitudinal dispersivity for the aquifer and ten percent for the upper clay soils. These values all represent assumptions which are reasonable for the conditions at the GSS and are in line with common practice.

Site-specific values for molecular diffusion were not available. This is nearly always true in site investigations, and this parameter is not generally considered to be significant. A literature value of 9.3×10^{-5} ft^2/day (1×10^{-7} cm^2/sec) was used for all model layers. The effects of varying this value are addressed in the sensitivity analysis in Section 5.

MODELED ALTERNATIVES

The model was developed as a means to predict the impact of the Site soils on the groundwater beneath the Site and to aid in the evaluation of options for the remediation of impacted soils. The model was used to evaluate four general alternatives: no action, maintenance pumping, soil remediation to 1,000 μg/kg, and soil remediation to 5,000 μg/kg total VOCs.

No Action

This alternative is presented only for comparison. The alternative involves an end to pumping from extraction wells at the GSS and the movement of contaminated groundwater toward the Granville wellfield. The calibrated model, with the upper clay soil vertical conductivity set at 0.028 ft/day was used for the initial simulation. The initial concentrations of TCE used for the aquifer in the calibrated model were based on two-year-old sampling data for the aquifer. Given that the pump and treat system has removed some of the TCE mass in two years of operation, the plume generation indicated for this scenario is probably overestimated. Actually, this simulation more closely approximates conditions where no treatment system had been installed at the GSS.

The results of this simulation indicated the arrival of groundwater above 5 μg/L in TCE concentrations at Granville wellfield (well PW-2) within 6 years. The TCE impact (above 5 μg/L) spreads to well PW-3 and continues through the 30 year period of the simulation. Well PW-4 was not impacted in this simulation, because wells PW-2 and PW-3 intercepted the plume. Realistically, if wells PW-2 and PW-3 were to become impacted, those wells would be sequentially shut down and well PW-4 would become impacted.

Maintenance Pumping

The calibrated model was used to evaluate the alternative in which extraction well EW-2 is pumped at 320 gpm for 5 years and then pumped at a maintenance level of 40 gpm for an additional 15 years. Flux from the clay soils to the pumping well was allowed over the entire model run. This alternative was evaluated at each of three vertical hydraulic conductivity values for the upper clay soils. The values were varied by two orders of magnitude from 1 x 10^{-5} cm/sec to 1 x 10^{-7} cm/sec. These conductivity values are assumed to cover reasonable level of uncertainty for this type IV parameter.

The simulation using a vertical hydraulic conductivity in the upper soils of 1 x 10^{-5} cm/sec resulted in no regeneration of the 5 μg/L plume after pumping ceased in 20 years. Only a small mass of TCE remained in the upper clay soils after 30 years. The maximum TCE concentration in the pore water of the clay soil was 60 μg/L after 20 years and declined to 18 μg/L after 30 years.

The simulation using a vertical hydraulic conductivity for the upper clay soils of 1 x 10^{-6} cm/sec resulted in slight plume regeneration after 20 years of pumping. The maximum horizontal extent of the 5 μg/L plume was 125 feet from the edge of the impacted clay soil and remained within the bounds of the GSS. The maximum depth of the 5 μg/L plume was 885 feet amsl or about 15 feet below the top of the aquifer. After 20 years, the maximum TCE concentration in the upper clay soil pore water was 200 μg/L. After 30 years the maximum concentration had declined to 160 μg/L.

The simulation using a vertical hydraulic conductivity in the upper clay soils of 1 x 10^{-7} cm/sec (approximately the value obtained from the laboratory vertical permeability tests) resulted in a slight plume regeneration after 30 years. The maximum extent of the 5 μg/L plume was approximately 90 feet. However, a relatively large concentration of TCE remained in the soils after 30 years (1,600 μg/kg). To ensure that the plume would not extend farther after 30 years, the simulation was continued to 60 years. The maximum plume extent after 32 years was 105 feet, and its maximum depth was to elevation 889 feet amsl, or about 11 feet below the top of the aquifer. At 60 years in the simulation, the maximum TCE concentration was 1,000 μg/kg in the upper clay soils.

The range of values for vertical conductivity of the upper clay soils was sufficient to include all reasonable outcomes on which to base conclusions. Conductivities higher than 1 x 10^{-5} cm/sec would result in no plume regeneration at 20 years due to the small TCE mass remaining in the clay soils after 20 years of leaching. Conductivities lower than 1 x 10^{-7} cm/sec would result in little or no plume generation due to the very slow addition of TCE from the upper clay soils. The plume resulting from simulation with a vertical conductivity of 1 x 10^{-6} cm/sec for the upper clay soils was the largest for the three simulations and represents the worst case scenario for these alternatives. That scenario resulted in a small plume that remained confined to the GSS property.

The affects of potential DNAPLs on the outcome of this scenario could be significant. The affect on each of the three simulations would be to provide more TCE mass in the soil at the end of the 20 year period. In all simulations. this would result in the generation of a larger plume.

Soil Remediation to 1,000 μg/kg TCE

This alternative involved soil treatment or removal for soils with TCE concentrations greater than 1,000 μg/kg. When deep soils are treated or removed, the soils above them were assumed also to be treated, even if the shallower soils had TCE concentrations less than 1,000 μg/L. Thus, while soils at 15 feet below the ground surface were assumed treated or removed to the 1,000 μg/kg level, shallower soils were typically treated to lower levels. Approximately 6,000 cubic yards of soil were estimated to have been treated or removed for this alternative.

This alternative included the pumping of EW-2 at 320 gpm for 5 years. This is the assumed time period required to remove the groundwater contaminant plume. After 5 years, EW-2 was shut off without maintenance pumping. This alternative was evaluated for each of four vertical hydraulic conductivity values for the upper clay unit. The values ranged greater than two orders of magnitude from 5 x 10^{-5} cm/sec to 1 x 10^{-7} cm/sec. The range of conductivity values were assumed to span any reasonable range of uncertainty in this type IV parameter.

The simulation with the vertical conductivity if the upper clay soil of 5 x 10^{-5} cm/sec resulted in no plume generation. Essentially all of the TCE contained in the soils was leached by the time the pump was turned off in five years. The maximum TCE concentration in water in the clay soil at five years (end of pumping) was 2 μg/L. This conductivity value is not realistic for these soils but it provides an upper limit for the TCE leaching and demonstrates that higher conductivities are not an issue for potential impact to the wellfield.

The simulation with a vertical conductivity of the upper clay soil of 1 x 10^{-5} cm/sec resulted in a small 5 μg/L plume after five years. The maximum extent of the plume was 90 feet from the source, within the property of the GSS. The maximum depth of the plume was 893 feet amsl, or 7 feet below the top of the aquifer. These values were for 10 years, or five years after pumping stopped. The maximum TCE concentration in water in the clay soil after 10 years was 40 μg/L. At 20 years, the maximum concentration was 16 μg/L, and at 30 years it was 6 μg/L.

The simulation with a vertical conductivity for the upper clay soils of 1 x 10^{-6} cm/sec resulted in no generation of a 5 μg/L plume. The maximum TCE concentration in water in the clay soils at 10 years was 140 μg/L. At 20 years the maximum was 100 μg/L, and at 30 years it was 80 μg/L.

The simulation with a vertical conductivity for the upper clay soils of 1 x 10^{-7} cm/sec also resulted in no plume generation. The maximum TCE concentrations remaining in the water in the clay soil were 180 μg/L after 10 years, 160 μg/L after 20 years, and 140 μg/L after 30 years.

A worst case model result for this alternative is a plume extending approximately 90 feet from the source. This is not an off-site plume, and the plume would have to expand approximately 15 times this distance to impact the nearest active well in the Granville wellfield (PW-2).

The affects of the potential presence of DNAPLs for this scenario are minimal. Treating all soils with TCE concentrations greater than 1,000 μg/kg should remove any potential source areas with DNAPLs. If DNAPLs were present in the clay soil they would be associated with high soil concentrations. Areas with high TCE concentration were identified in the soil investigation and would be treated as part of this alternative.

Soil Remediation to 5,000 μg/kg TCE

For this alternative, all clay soils with TCE concentrations greater than 5,000 μg/kg were assumed to have been removed by excavation or treated by other methods to remove the contaminant. When deeper soils were treated, the soils above them were also considered to be treated, even if the shallower soils had TCE concentrations less than 5,000 μg/kg. Thus, while soils, at 15 feet below the ground surface, were treated to the 5,000 μg/kg level, shallower soils were typically treated to levels closer to 1,000 μg/kg. About 3,000 cubic yards of soil were estimated to have been treated or removed.

This alternative also included the pumping of extraction well EW-2 at 320 gpm for 5 years. This is the assumed time period required to remove the contaminant plume from the aquifer. After 5 years, EW-2 was shut off without maintenance pumping. This alternative was evaluated at each of four vertical hydraulic conductivity values for the upper clay soils. The values ranged from 5 x 10^{-5} cm/sec to 1 x 10^{-7} cm/sec. The range in upper clay soil vertical conductivity values was assumed to cover any reasonable range of uncertainty in this type IV parameter.

The simulation with the vertical conductivity of the upper clay soil of 5 x 10^{-5} cm/sec resulted in no plume generation. Essentially all of the TCE contained in the clay soils was removed by the time the pump was turned off after five years. The maximum TCE concentration in the pore water of the clay soils after five years was 5 μg/L. This high conductivity is probably not realistic for the clay soils, but it provides an upper limit for TCE leaching and demonstrates that higher conductivities are not an issue for potential impact to the wellfield.

The simulation of 1 x 10^{-5} cm/sec in the upper clay soils resulted in a small 5 μg/L plume after five years. The maximum extent of the plume was 280 feet from the soil source. This is beyond the property of the GSS. The maximum depth of the plume was 881 feet amsl, or 19 feet below the top of the aquifer. These maximum values were obtained at 10 years (or five years after the pumps had been turned off). The maximum TCE concentration in the clay soil pore water at 10 years was 100 μg/L. At 20 years, the maximum concentration was 35 μg/L, and at 30 years it was 12 μg/L. Thus, with this relatively high conductivity for the upper clay soils, a small plume was generated but the maximum extent of the plume was just beyond the property boundaries and the plume receded after 10 years.

The simulation with a vertical conductivity for the upper clay soils of 1 x 10^{-6} cm/sec resulted in no development of a 5 μg/L plume. The maximum TCE concentration in the clay soil pore water after 10 years was 200 μg/L. After 20 years the maximum was 180 μg/L, and after 30 years it was 140 μg/L.

The simulation with a vertical conductivity in the upper clay soils of 1 x 10^{-7} cm/sec (closest to the laboratory permeability values) also resulted in no plume generation. The maximum TCE concentrations remaining in the clay soil water were 450 μg/L after 10 years, 350 μg/L after 20 years, and 300 μg/L after 30 years.

A "worst case" model result for this alternative is a plume generation of approximately 280 feet from the contaminant source. This does represent an off-site plume, but it does not come close to impacting the Granville wellfield. The plume would have to extend to five times this distance to impact the nearest well in the wellfield (PW-2).

The affects of the potential presence of DNAPLs for this scenario are minimal. Treating the soil to a level of 5,000 μg/kg should remove any potential source areas with DNAPLs. The presence of DNAPLs in the clay soil would be associated with high concentration soils; these soils have been identified in the soil investigation and would be treated as part of this alternative.

MODELED ALTERNATIVES EVALUATION

Of the four alternatives evaluated, only the no action alternative is unacceptable. This conclusion is based on evaluation of the alternatives using a calibrated groundwater flow model combined with a contaminant fate and transport model. The sensitivity of the model was thoroughly evaluated prior to simulating the alternative scenarios. The primary parameter with type IV sensitivity was the vertical hydraulic conductivity of the impacted upper clay soils. The uncertainty introduced by this parameter was carefully controlled as part of the simulation of alternatives.

The affects of potential residual DNAPLs in the upper clay soil were not directly evaluated by the model. However the potential presence of DNAPLs was evaluated qualitatively outside of the modeling effort for each alternative. It was determined that maintenance pumping to year 20 with no active soil remediation was relatively sensitive to potential DNAPLs, while TCE clean-up to 1,000 μg/kg and 5,000 μg/kg levels, respectively, are not likely to be sensitive to residual DNAPLs.

There is no apparent reason to choose to remediate the soils to the 1,000 μg/L levels rather than 5,000 μg/L. Part of the reason for this is that some clay soil with TCE concentrations less than 5,000 μg/L would have to be treated or removed in the process of treating or removing 5,000 μg/kg clay soils at depth. Soils in the upper five feet would be effectively treated to levels of 1,000 μg/kg. Overall, the additional removal or treatment of 3,000 cubic yards of soil to go from alternative 3 to alternative 4 does not seem to be justified.

SUMMARY

Soil remediation to the total VOC level of 5,000 μg/kg remains protective of human health. The results of the risk characterization for the excavation worker and hypothetical future industrial worker demonstrated that chemicals of concern in soil that were at least twice the proposed soil remediation level of 5,000 μg/kg were not associated with unacceptable risk. Therefore, the risk associated with 5,000 μg/kg would be acceptable as well.

The conclusion drawn from the model results indicate that the no action alternative would allow compounds presently in the Site soils to migrate into the wellfield at concentrations above the no further action levels. Maintenance pumping involves the use of GSS-EW2 at relatively high flow rates for a period of 5 years and a reduced rate for a period of 15 years. The evaluation of this modeled alternative concluded that over time the groundwater concentration would be reduced to concentrations below the no further action levels. The model results are relatively sensitive to the potential for higher concentrations or non-aqueous phase liquids which might require longer-term pumping.

The model was used to simulate the removal of contaminants that exceed concentrations of 1,000 μg/kg. The results of the model simulation were interpreted to indicate that the groundwater concentrations would not exceed the no further action levels. Because the soil contaminants exceeding a concentration of 1,000 μg/kg were removed, the potential effects that might be caused by unknown higher concentrations or non-aqueous phase liquids are minimized.

The model was also used to simulate the removal of contaminants that exceed concentrations above 5,000 μg/kg. The interpretation of the model results for the removal of soil contaminants above a concentration of 5,000 μg/kg is that it will have essentially the same effect as the removal of soil contaminants with concentrations above 1,000 μg/kg.

The conclusion drawn for the modeling effort is that the removal of soil contaminants to concentrations 5,000 μg/kg or less will meet the requirements of the Administrative Order to "Treat soils, ...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels." (Section V.2.g).

2.5.7 Summary of Risk Evaluation and Removal Action Goals for the Treatment of Impacted Soils

The streamlined risk evaluation for the GSS evaluated the potential significance of contact with volatile organic chemicals in soils on the property. Analytical soil data generated during the April 1996 Site investigation were used to select the chemicals of concern and maximum concentrations of those chemicals to quantitatively estimate exposures to people who may feasibly come into contact with the soil on Site.

One group of potentially exposed individuals could be identified as being likely receptors to come into contact with Site soils at GSS, namely, excavation workers who excavate utility corridors on the Site. However, because the site is zoned industrial and is located near other industrial sites, a hypothetical future industrial worker was also identified as being a remote potential receptor.

The methods used to estimate the intake of chemicals from soil on the GSS incorporated assumptions and variable values which are consistent with U.S. EPA and Ohio EPA guidance documents.

The estimated risks from direct contact (ingestion, dermal contact, and inhalation) with chemicals in the soil were of a very low order of magnitude for both carcinogenic and noncarcinogenic health effects.

Based upon the results of this streamlined risk evaluation, maximum concentrations of the volatile organic chemicals detected in GSS soil are not associated with an excess carcinogenic risk or adverse health effect. It is not necessary to take action for these exposures. Therefore, Removal Action Goals for the treatment of impacted soils based on an excavation scenario and industrial scenario were not derived.

The human populations, individuals, or receptors who could feasibly be exposed to chemicals from the site are key to the process of developing the Removal Action Goals. As stated in the text above, direct contact with soil for the feasible receptors at the GSS is not associated with adverse health effects. Thus, the Removal Action Goal was developed to provide protection from groundwater assuming that chemicals in soil have the potential to migrate to groundwater and be transported in groundwater to a receptor point. Therefore, to be protective of groundwater while continuing to be protective of human health, soil contaminants with total VOC concentrations above 5,000 μg/kg will, if removed, more quickly and permanently protect groundwater beneath the Site. Therefore, the Soil Treatment Goal for total VOCs in Site soils is 5,000 μg/kg.

3.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

3.1 STATUTORY LIMITS

No statutory limits have been identified.

3.2 DETERMINATION OF REMOVAL ACTION SCOPE

The scope of the Removal Action is defined by the Administrative Order, Section V.2(g). The scope is defined by the following orders:

1) *"By December 20, 1994, install and run a groundwater extraction and treatment system which shall halt the migration of groundwater contamination (originating from the Site) toward the Village of Granville municipal wellfield. Treat and discharge all extracted water as required by the Work Plan and this Order."*

2) *"In addition, implement action which is necessary to ensure that any water contaminated with any contamination (originating from the Site) that enters the Village of Granville municipal wellfield drinking water supply meets all risk-based and all applicable federal and state drinking water standards. Such action may include utilization of, modification to, and/or addition to the Village of Granville municipal wellfield drinking water supply system. (For example, such action may be, or include, wellhead treatment which meets the performance standards of this Order; or, may be, or include, the installation of an appropriate alternative water supply.) Such action shall be implemented at the Village of Granville municipal wellfield to the extent necessary both to reinstate fully the capacity of PW-1 prior to its reactivation and to the extent necessary to prevent any loss in the Village of Granville municipal wellfield drinking water supply capacity (i.e., the collective capacity of PW-1, PW-2, and PW-3) caused, in whole or in part, because of contamination (originating from the Site), or the threat thereof, entering the Village of Granville municipal wellfield water supply."*

3) *"Design, install, and operate a groundwater extraction and treatment system which shall halt the migration of groundwater contamination (originating from the Site) toward the Village of Granville municipal wellfield and shall treat all groundwater within the contamination plume*

originating from the Site to no further action levels which assure protection of human health and the environment and attain all risk-based standards and federal and state ARARS."

4) *"Treat the soils at the Site to levels which will assure protection of human health and the environment, to levels which will attain all risk-based standards and federal and state ARARs, and to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels. Respondents shall propose a schedule to develop soil treatment objectives, no further action levels, performance monitoring parameters, and a plan for treatment of the soils, in the draft Work Plan."*

3.3 DETERMINATION OF REMOVAL ACTION GOALS

As described in Section 2 of this document, the Removal Action Goals for the treatment of impacted soils that will meet the stated requirements have been developed by modeling the fate and transport of compounds detected in the subsurface soils at the Site, and characterizing the risk posed by the residual compounds in Site soils. The Remedial Action Goal for treatment of impacted soil is treatment of soil containing total VOCs that exceed 5,000 μg/kg.

3.4 DETERMINATION OF REMOVAL ACTION OBJECTIVES

The proposed removal action objectives are as follows:

- Reduce the mass of contaminants present in the subsurface soil by the application of an alternative that will address the soils which exceed approximately 5,000 μg/kg of the total VOCs.

- Maintain a groundwater contaminant and removal system such that impacted groundwater exceeding action levels does not migrate into the Village of Granville wellfield.

- Maintain a groundwater contaminant and removal system such that compounds present in the subsurface soil that remain following the removal action on the soil do not impact the groundwater, to the extent practicable; above groundwater no further action levels.

- Enhance the groundwater removal system to more effectively and efficiently remove contaminant mass from the groundwater.

3.5 DETERMINATION OF REMOVAL ACTION SCHEDULE

The proposed schedule for the removal action is presented on the following table[1].

Activity	Number of Calendar Days Following Completion of Previous Activity
1. Submit EE/CA	0
2. Meet with U.S. EPA	30
3. Submit Final EE/CA After Receipt of Comments	90
4. Receive Final Approval	30
5. Public Meeting	30
6. Respond to Public Comments	30
7. Notice to Proceed to Construction	
8. Commence Construction	
9. Commence Operation	
10. Removal Action Completion	

[1] Subject to weather, equipment availability, and other *force majeure* events.

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4.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

Previously, M&E had evaluated a wide range of technologies that might be effective in meeting the requirements of the AOC. This work has been summarized in the *Design Technical Memorandum* (1995). As a result, several technologies have been eliminated and five have been carried forward for consideration. These alternatives fall into two broad categories: no action and soil contaminant removal with groundwater treatment. For those alternatives with soil contaminant removal, the Removal Action Goals have been determined based on contaminant fate and transport modeling which has been described in Section 2. Below is a brief description of each alternative, followed by an analysis of these alternatives.

4.1 IDENTIFICATION OF ALTERNATIVES

4.1.1 Alternative 1 - No Action

The "No Action" alternative would involve taking no action on the impacted soil detected at the Site and allowing natural leaching and degradation of the compounds present. Additionally, the current groundwater pump and treat system would be maintained and operated at its present status for a period of three years, and at a lower maintenance level for at least 17 additional years.

This alternative does not provide overall protection of human health and the environment, does not comply with ARARs, does not provide long-term effectiveness or permanence, nor does it provide short-term effectiveness. This alternative is retained in this analysis only as a means to provide a baseline against which other alternatives are compared and to be consistent with applicable regulatory guidance.

4.1.2 Alternative 2 - Soil Removal by Excavation and Disposal

Alternative 2 consists of the excavation and off-site disposal of soil based on the contaminant fate and transport modeling described in Section 2.5. Soils impacted by total volatile organic compounds in concentrations in excess of 5,000 μg/kg would be removed by excavating and disposing these materials off-site. These soils are generally located beneath the area currently occupied by the warehouse building at depths of greater than six feet to the water table. The estimated volume of this material is approximately 8,000 yd^3. To excavate the material, sheet piling would be installed to eliminate the need to remove additional material.

The current groundwater pump and treat system would be modified by the addition of a new extraction well, GSS-EW3, located near current monitoring well P-1 as described in the *Fate and Transport Modeling Report* (1996). This well would be screened to intercept the more highly impacted groundwater near the surface of the water table. This system would operate for approximately five years, after which time GSS-EW3 would extract at a maintenance pumping rate for a period of five years to capture leaching of residual soil contamination over that period of time.

The groundwater monitoring program is anticipated to be maintained at its current level and at a reduced level for a period of 10 years prior to closure.

4.1.3 Alternative 3 - *In-Situ* Mixing/Hot Gas Vaporization of Soil Areas

Alternative 3 consists of the removal of soil contaminants by soil mixing and hot gas vaporization. The soil area is the same as described in Alternative 2. Soils overlying this area would be treated incidentally by this method resulting in a total volume of 8,000 yd^3 of soil treated.

The groundwater pump and treat system would be modified and operated as described in Alternative 2. In addition, the groundwater monitoring program is expected to be the same as in Alternative 2.

4.1.4 Alternative 4 - Treatment of Soils by Pneumatic Fracturing and Soil Vapor Extraction

Alternative 4 would consist of the removal of the contaminants by the use of soil vapor extraction enhanced by pneumatic fracturing. The soil area is the same as previously described in Alternative 2. The soils overlying the area are expected to be remedied by induced airflow from the SVE system.

The groundwater pump and treat system would be modified and operated as described in Alternative 2. The groundwater monitoring program is expected to be as described in Alternative 2.

4.1.5 Alternative 5 - Treatment of Soils Via Thermally Enhanced Soil Vapor Extraction (Shell Process)

Alternative 5 would consist of the removal of contaminants by the application of an innovative technology that heats the soil with electrodes, draws a vacuum on the electrodes to recover and destroy the contaminants, while the formation desiccates, causing increased air permeability. The area is the same as described in Alternative 2.

The pump and treat system would be modified and operated as described in Alternative 2. The groundwater monitoring program would be expected to be maintained as described in Alternative 2.

4.2 ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section provides a comparative analysis of the Removal Action Alternatives in tabular form and a cost analysis, also in tabular form. Section 4.2.1 consists of a series of five tables that identify, evaluate the effectiveness and implementability, and estimates the cost of each alternative.

4.2.1 Comparative Analysis

The comparative analysis is provided in Tables 4-1 through 4-5. Each alternative is evaluated as to its anticipated effectiveness based on the following criteria:

1) Overall protection of human health and the environment;
2) Compliance with ARARs and other criteria, advisories, and standards;
3) Long-term effectiveness and permanence;
4) Reduction of toxicity, mobility, and volume through treatment; and
5) Short-term effectiveness.

Implementability is evaluated based on the following criteria:

1) Technical feasibility;
2) Administrative feasibility;
3) Availability of services and materials;

4) State acceptance; and

5) Community acceptance.

4.2.1.1 Alternative 1 - No Action

EFFECTIVENESS

Overall Protection of Human Health and the Environment:

If no action for removal or treatment is taken on contaminants in the soils, natural leaching and degradation of the contaminants would ultimately lead to their disappearance from the site soils. Soil contaminants would continue to migrate into the groundwater beneath the site and be collected by the groundwater treatment system. Established cleanup levels would not be achieved, nor would there be compliance with AOC requirements.

Extraction and treatment of Site groundwater would be necessary at the current rate for at least 3 years and at a lower rate for approximately 17 years.

Compliance with ARARs and Other Criteria, Advisories, and Guidance:

No treatment measures would be taken to reduce soil contaminant concentrations. Natural leaching of the chemicals and degradation would bring contaminant levels in the soils below established cleanup levels over time. However, this alternative does not comply with the AOC requirement that soils be treated "...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels."

Moreover, the alternative does not comply with the AOC requirement for treating "...all groundwater within the contamination plume originating from the site to no further action levels which assure protection of human health and the environment and attain all risk-based standards and federal and state ARARs."

Long-Term Effectiveness and Permanence:

There would ultimately be no residual risk for the soils if the soil contaminants are left to naturally degrade and leach into the groundwater. Residual risk for the Site groundwater would continue over the long-term because the soil contaminants would continue to contribute to the Site groundwater contamination. Thus, in the long term, the no action alternative would not be effective or permanent.

Reduction of Toxicity, Mobility, and Volume Through Treatment:

No treatment of soil contaminants is provided under the no-action alternative, but the natural processes of leaching and degradation would, over time, transfer soil contaminants into the groundwater. Because there would be a transfer of contaminants into another more mobile medium, there would be increases in toxicity, mobility, and volume for that medium.

Short-Term Effectiveness:

The absence of any remedial action for the soil under the no-action alternative indicates that no short-term impacts to the community or the environment will occur because there is no implementation. Contaminants leaching from the soil will ultimately increase the potential impacts from the groundwater.

IMPLEMENTABILITY

Technical Feasibility:

No technical feasibility considerations exist in the absence of any measures being taken to treat or remove the contaminants.

Administrative Feasibility:

Administrative difficulties are anticipated because no proactive measures would be taken to reduce contaminant levels below established cleanup levels, and AOC requirements to perform treatment will not be followed.

Availability of Services and Materials:

Availability of services and materials is not an issue for the no-action alternative, based on the absence of any protective measures taken to treat or remove the contaminants.

State Acceptance:

State acceptance would probably not be possible to obtain because no actions will be taken to reduce contaminant levels to below established cleanup levels and AOC requirements will not be followed.

Community Acceptance:

Community acceptance would probably not be possible to obtain because no actions will be taken to reduce contaminant levels to below established soil cleanup levels and AOC requirements will not be followed.

4.2.1.2 Alternative 2 - Soil Removal by Excavation and Disposal

EFFECTIVENESS

Overall Protection of Human Health and the Environment:

Soil excavation and disposal of those soils that exceed 5,000 μg/kg total VOCs will provide a high degree of overall protection of human health and the environment. Soil excavation and disposal would reduce the quantity of soil contaminants migrating into the Site groundwater, permanently removing soil contaminants from the Site soil. Moreover, it will comply with ARARs by satisfying the AOC requirements and be protective of the community, site workers, and the environment during implementation through effective Site control measures.

With the continued extraction and treatment of the Site groundwater at a high flow rate (about 300 gpm) for an estimated 5-year period, the groundwater plume is expected to have receded to beneath the area of the Site. Maintenance pumping at a low flow rate (about 40 gpm) would be required to continue for an additional 5 years.

Compliance with ARARs and Other Criteria, Advisories, and Guidance:

Soil excavation and disposal is a proven technology and would remove and dispose approximately 5,100 cubic yards of soils containing contaminants at levels above established soil cleanup levels. Soil excavation and disposal combined with continued extraction and treatment of the site groundwater complies with the AOC requirements that soils be treated ... "to levels which assure, to the maximum extent practicable, that no groundwater beneath the soils becomes contaminated above groundwater no further action levels."

Long-Term Effectiveness and Permanence:

Soil excavation and disposal will be effective in reducing the migration of soil contaminants into the site groundwater. Natural leaching and degradation of contaminants in the soils outside the area impacted above 5,000 μg/kg will reduce soil contaminant levels. These contaminants will be removed through continued operation of the groundwater treatment system.

Reduction of Toxicity, Mobility, and Volume Through Treatment:

Soil excavation and disposal would remove all soils containing volatile organic contaminants at concentrations above soil cleanup levels. Soil excavation and disposal would reduce the toxicity, mobility, and volume of the volatile organic contaminants in the Site soils (by their removal).

Soil excavation and disposal from the site represents an irreversible process for the site, but transport and disposal at a regulated, permitted hazardous waste landfill overall reduces toxicity and mobility but not volume.

Residual soil contaminants would degrade or leach into the groundwater and be captured by the groundwater treatment system. This will result in the elimination of soil contaminant toxicity, mobility, and volume through treatment.

Short-Term Effectiveness:

Risk to the nearby residents resulting from soil removal and disposal would be minimized by the implementation of effective Site controls. Impacts to Site workers during implementation of this remedial action would be minimized by ensuring that proper personal protective equipment is provided and used.

The implementation of this alternative is not expected to impose any measurable environmental impacts. The soil excavation and disposal alternative could be effectively implemented within 6 to 9 months of on-site activity. The treatment of residual soil contaminants outside the area impacted by total VOCs in excess of 5,000 μg/kg would occur through continued operation of the groundwater treatment system. The estimated time to reduce residual soil contaminant concentrations to levels which are protective of groundwater is 10 years.

IMPLEMENTABILITY

Technical Feasibility:

Soil excavation and removal is a technically feasible but impractical option inasmuch as nonconventional construction techniques would be required for its implementation. All proposed groundwater extraction and treatment technologies have been demonstrated as technically feasible.

Administrative Feasibility:

The implementation of this alternative is considered administratively feasible. But Site controls to prevent off-site dispersion of airborne contaminants would be needed.

Availability of Services and Materials:

Conventional construction equipment and adequate disposal sites, along with the personnel required to operate it, are readily available. There are no foreseen problems associated with obtaining the services, materials, equipment, and disposal sites necessary to implement this alternative.

State Acceptance:

State acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment.

Community Acceptance:

Community acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment. Truck traffic to and from the Site could be a community consideration.

4.2.1.3 Alternative 3 - *In-Situ* Mixing/Hot Gas Vaporization of Soil Areas

EFFECTIVENESS

Overall Protection of Human Health and the Environment:

The soil mixing alternative will provide a high degree of overall protection of human health and the environment. *In-situ* mixing/vaporization treatment of soils exceeding 5.000 μg/kg should effectively reduce the migration of soil contaminants into the Site groundwater: permanently remove soil contaminants from the Site soil; comply with ARARs by satisfying the AOC requirements; and be protective of the community, Site workers, and the environment during implementation through the implementation of effective Site control measures.

Continued extraction and treatment of the Site groundwater at a high flow (about 300 gpm) would be required over an estimated 5-year period and maintenance pumping at a low flow rate (about 40 gpm) would continue an additional 5 years.

Compliance with ARARs and Other Criteria, Advisories, and Guidance:

In-situ mixing/vaporization is a proven technology and is expected to reduce contaminant concentrations below established soil cleanup levels of 5,000 μg/kg. This treatment technology and the continued extraction and treatment of Site groundwater are expected to comply with the AOC requirement that soils be treated "...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels."

Long-Term Effectiveness and Permanence:

The *in-situ* mixing/vaporization technology is expected to be effective in eliminating the migration of soil contaminants into the Site groundwater. Natural leaching and degradation of remaining contaminants in the soils will reduce soil contaminant levels. These contaminants will be removed through continued operation of the groundwater treatment system.

Reduction of Toxicity, Mobility, and Volume Through Treatment:

The *in-situ* mixing/vaporization technology is expected remove at least 90 percent of the volatile organic contaminants in soils that are treated. *In-situ* mixing/vaporization will reduce the toxicity, mobility, and volume of the volatile organic contaminants in the Site soils and satisfy statutory preferences for treatment. *In-situ* mixing/vaporization is an irreversible treatment process. Residual soil contaminants would degrade or leach into the groundwater and be captured by the groundwater treatment system. This will result in the elimination of soil contaminant toxicity, mobility, and volume through treatment.

Short-Term Effectiveness:

Risk to the nearby residents resulting from the *in-situ* treatment of the Site soils with this alternative would not be measurable. The design of the *in-situ* mixing/vaporization treatment process will incorporate collection and treatment of the off-gases to control airborne organic compounds. Impacts to Site workers during implementation of this remedial action would be minimized by ensuring that proper personal protective equipment is provided and used. The implementation of this alternative is not expected to impose any measurable environmental impacts.

The estimated time to implement treatment of the soils and reduce soil concentrations below the established soil cleanup levels is less than three months. The treatment of residual soil contaminants not removed would occur through continued operation of the groundwater treatment system. The estimated time to reduce residual soil contaminant concentrations to levels which are protective of groundwater is 10 years.

IMPLEMENTABILITY

Technical Feasibility:

The *in-situ* soil mixing/hot gas vaporization technology is considered a technically feasible and reliable remedial option for the Site soil contaminants. All proposed groundwater extraction and treatment technologies have been demonstrated as technically feasible. The large cranes and mixing equipment required to implement this technology may have difficulty in accessing and moving around the project Site (e.g., overhead utilities, sloped topography, and the small size of the Site).

Administrative Feasibility:

The implementation of this alternative is considered administratively feasible. The off-gas treatment for the *in-situ* mixing technology may require an air permit-to-install or an exemption.

Availability of Services and Materials:

The *in-situ* mixing/vaporization technology, along with personnel required for implementation, is readily available. The services and materials necessary to implement this alternative are readily available.

State Acceptance:

State acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment.

Community Acceptance:

Community acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment. The large cranes and mixing equipment needed to treat the soils with the *in-situ* mixing technology could be a community consideration.

4.2.1.4 Alternative 4 - Treatment of Soils by Pneumatic Fracturing and Soil Vapor Extraction

EFFECTIVENESS

Overall Protection of Human Health and the Environment:

Successful pneumatic fracturing and SVE treatment of impacted soils with total VOC concentrations in excess of 5,000 μg/kg would provide a high degree of overall protection of human health and the environment. Pneumatic fracturing and SVE treatment would effectively reduce the migration of soil contaminants into the Site groundwater; permanently remove contaminants from the soil (within an estimated 5-year time period); comply with ARARs by satisfying the AOC requirements; and be protective of the community, Site workers, and the environment during implementation.

Continued extraction and treatment of the Site groundwater at a high flow (about 300 gpm) would be required over an estimated 5-year period and maintenance pumping at a low flow rate (about 40 gpm) would continue an additional 5 years.

Compliance with ARARs and Other Criteria, Advisories, and Guidance:

SVE treatment is a proven technology and will reduce contaminant concentrations below established cleanup levels. Successful application of pneumatic fracturing and SVE treatment and continued extraction and treatment of Site groundwater are expected to comply with AOC requirement that soils be treated "...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels."

Long-Term Effectiveness and Permanence:

Successful application of pneumatic fracturing and the SVE treatment would be effective in eliminating the migration of soil contaminants into the groundwater (within an estimated 5-year time period). Natural leaching and degradation of contaminants in the soils outside the area underlain by soils with total VOC concentrations greater that 5,000 μg/kg will reduce soil contaminant levels. These contaminants will be removed through continued operation of the groundwater treatment system.

Reduction of Toxicity, Mobility, and Volume Through Treatment:

Successful pneumatic fracturing and SVE treatment would be expected to remove 90% of the volatile organic contaminants in the soils that are treated. Successful pneumatic fracturing and SVE treatment would reduce the toxicity, mobility, and volume of the volatile organic contaminants in the soils and satisfy statutory preferences for treatment. SVE is an irreversible treatment process.

Residual soil contaminants would degrade or leach into the groundwater and be captured by the groundwater treatment system. This will result in the elimination of soil contaminant toxicity, mobility, and volume through treatment.

Short-Term Effectiveness:

Risk to the nearby residents resulting from the operation of the SVE treatment system would not be measurable. If necessary, controlled air emissions from the SVE treatment system could be incorporated into the system design. Impacts to Site workers during implementation of this remedial action would be minimized by ensuring that proper personal protective equipment is provided and used.

The implementation of this alternative is not expected to impose any measurable environmental impacts. The estimated time to reduce soil contaminant concentrations in the area below the established cleanup levels with successful pneumatic fracturing and SVE treatment is less than 5 years. The treatment of residual soil contaminants outside the area would occur through continued operation of the groundwater treatment system. The estimated time to reduce residual soil contaminant concentrations to levels which are protective of groundwater is 5 years.

IMPLEMENTABILITY

Technical Feasibility:

The SVE technology, with enhancements to the technology using pneumatic fracturing to improve soil permeability, should be technically feasible for the Site soil contaminants. A final judgement on technical feasibility will be made after a pilot application of the technology has been performed at the Site. All proposed groundwater extraction and treatment technologies have been demonstrated as technically feasible.

Administrative Feasibility:

The implementation of this alternative is considered administratively feasible. Dependent upon the concentration of volatile organic compounds in the vapor extraction system off-gas, an air permit-to-install or an exemption may be necessary for the SVE system.

Availability of Services and Materials:

The SVE and pneumatic fracturing technologies, along with the personnel required to implement them, are readily available. The services and materials necessary to implement this alternative are readily available.

State Acceptance:

State acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment.

Community Acceptance:

Community acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment.

4.2.1.5 Alternative 5 - Treatment of Soils Via Thermally-Enhanced Soil Vapor Extraction

EFFECTIVENESS

Overall Protection of Human Health and the Environment:

Thermally-enhanced soil vapor extraction of soils with total VOCs greater than 5,000 μg/kg would provide a high degree of overall protection of human health and the environment. Thermally-enhanced soil vapor extraction would effectively reduce the migration of soil contaminants into the site groundwater; permanently remove contaminants from the soil; comply with ARARs by satisfying the AOC requirements; and be protective of the community, Site workers, and the environment during implementation.

Enhanced extraction and treatment of the Site groundwater at a high flow (about 300 gpm) would be required over an estimated 5-year period and maintenance pumping at a low flow rate (about 40 gpm) would continue an additional 5 years.

Compliance with ARARs and Other Criteria, Advisories, and Guidance:

Thermally-enhanced soil vapor extraction is an innovative technology that has been developed for the treatment of VOCs in clay soils and is expected to reduce contaminant concentrations below established cleanup levels. Successful application of the thermally-enhanced soil vapor extraction treatment process and continued extraction and treatment of Site groundwater are expected to comply with the AOC requirement that soils be treated "...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels."

Long-Term Effectiveness and Permanence:

Successful application of the thermally-enhanced soil vapor extraction treatment process is expected to be effective in eliminating the migration of soil contaminants into the groundwater. Natural leaching and degradation of contaminants not removed will reduce soil contaminant levels. These contaminants will be removed through continued operation of the groundwater treatment system.

Reduction of Toxicity, Mobility, and Volume Through Treatment:

Successful treatment by thermally-enhanced soil vapor extraction would almost quantitatively remove the volatile organic contaminants in the soils that are treated. Successful treatment by thermally-enhanced soil vapor extraction will reduce the toxicity, mobility, and volume of the volatile organic contaminants in the soils and satisfy statutory preferences for treatment.

Thermally-enhanced soil vapor extraction is an irreversible treatment process. Residual soil contaminants would degrade or leach into the groundwater and be captured by the groundwater treatment system. This would result in the elimination of soil contaminant toxicity, mobility, and volume through treatment.

Short-Term Effectiveness:

Risk to the nearby residents resulting from the operation of the thermally-enhanced soil vapor extraction system would not be measurable. All emissions from the thermally-enhanced soil vapor extraction system will be collected and treated in an on-site system to destroy any residual contaminants not destroyed *in-situ*. Impacts to site workers during implementation of this remedial action would be minimized by ensuring that proper personal protective equipment is provided and used.

The implementation of this alternative is not expected to impose any measurable environmental impacts. The estimated time to reduce soil contaminant concentrations to below the established soil cleanup levels with thermally-enhanced soil vapor extraction, including site preparation is 5 months. The treatment of residual soil contaminants would occur through continued operation of the groundwater treatment system. The estimated time to reduce residual soil contaminant concentrations to levels which are protective of groundwater is 10 years.

IMPLEMENTABILITY

Technical Feasibility:

The thermally-enhanced soil vapor extraction process should be a technically feasible and reliable remedial option for the Site soil contaminants. The first full-scale application of this technology is currently being conducted at a project site in Indiana. Further judgement on technical feasibility will be made once the results of the first full-scale application of this technology are available. All proposed groundwater extraction and treatment technologies have been demonstrated as technically feasible.

Administrative Feasibility:

The implementation of this alternative is considered administratively feasible. An air permit-to-install may be required for the discharge stack of the emissions control system of the thermally-enhanced soil vapor extraction system.

Availability of Services and Materials:

The equipment and personnel required to implement the thermally-enhanced soil vapor extraction system should be available within a reasonable time frame. If the thermally-enhanced soil vapor extraction process is demonstrated to be successful during the first full-scale application. problems associated with obtaining the services and materials necessary to implement this alternative are not anticipated.

State Acceptance:

State acceptance of this alternative would be likely based on its anticipated effectiveness. compliance with ARARs, and anticipated overall protection of human health and the environment.

Community Acceptance:

Community acceptance of this alternative would be likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment.

4.2.2 Cost Analysis

Cost analysis is provided in Table 4-6. The estimated costs are separated into the direct capital costs, indirect capital costs, annual O&M costs, and a net present worth of the long-term O&M costs. For each of these. estimates are made of the costs anticipated for the soil actions and the groundwater actions.

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TABLE 4-1
REMEDIAL ALTERNATIVE EVALUATION SUMMARY
GRANVILLE SOLVENTS SITE SOURCE AREA
GRANVILLE, OHIO

ALTERNATIVE	NCP EVALUATION CRITERIA		
	EFFECTIVENESS	**IMPLEMENTABILITY**	**ESTIMATED COSTS**
1. No Action on Soils Description • No-action on Soils • Existing Extraction System	*Overall Protection of Human Health and the Environment*: • No-action for removal or treatment would be taken on contaminants in the soils, but natural leaching and degradation of the contaminants would ultimately lead to their disappearance from the Site soils. • Soil contaminants would continue to migrate into the groundwater beneath the Site and be collected by the groundwater treatment system. Established cleanup levels would not be achieved, nor would there be compliance with AOC requirements. • Extraction and treatment of Site groundwater at the current rate for 3 years and at a lower rate for 17 years. *Compliance with ARARs and Other Criteria, Advisories, and Guidance*: • No treatment measures would be taken to reduce soil contaminant concentrations; natural leaching and degradation will bring contaminant levels in the soils below established cleanup levels. • Does not comply with the AOC requirement that soils be treated "...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels." • Does not comply with the AOC requirement for treating "...all groundwater within the contamination plume originating from the Site to no further action levels which assure protection of human health and the environment and attain all risk-based standards and federal and state ARARs." *Long-Term Effectiveness and Permanence*: • There would ultimately be no residual risk for the soils if the soil contaminants are left to naturally degrade and leach into the groundwater. Residual risk for the Site groundwater would continue over the long-term because the soil contaminants would continue to contribute to the Site groundwater contamination. Thus, in the long term, the no-action alternative would not be effective or permanent. *Reduction of Toxicity, Mobility, and Volume Through Treatment*: • No treatment of soil contaminants is provided under the no-action alternative, but the natural processes of leaching and degradation will, over time, transfer soil contaminants into the groundwater. • Because there would be a transfer of contaminants into another, more mobile medium, there would be increases in toxicity, mobility, and volume. *Short-Term Effectiveness*: • The absence of any remedial actions for the soil under the no-action alternative indicates that no short-term impacts to the community or the environment will occur because there is no implementation. Contaminants leaching from the soil will ultimately increase the potential impacts from the groundwater.	*Technical Feasibility*: • No technical feasibility considerations exist in the absence of any measures being taken to treat or remove the contaminants *Administrative Feasibility*: • Administrative difficulties are anticipated because no proactive measures will be taken to reduce contaminant levels below established cleanup levels, and AOC requirements to perform treatment will not be followed. *Availability of Services and Materials*: • Availability of services and materials is not an issue for the no-action alternative, based on the absence of any protective measures taken to treat or remove the contaminants. *State Acceptance*: • State acceptance would probably not be possible to obtain because no actions will be taken to reduce contaminant levels to below established cleanup levels and AOC requirements will not be followed. *Community Acceptance*: • Community acceptance would probably not be possible to obtain because no actions will be taken to reduce contaminant levels to below established soil cleanup levels and AOC requirements will not be followed.	Direct Capital Cost: Soil - None Groundwater - None Indirect Capital Cost: Soil - None Groundwater - None Annual O&M Cost: Soil - None Groundwater - $70,000 9 years, $31,000 11 years O&M Net Present Worth Cost: Groundwater - $638,384 Total Net Present Worth: $2,400,267

TABLE 4-2
REMEDIAL ALTERNATIVE EVALUATION SUMMARY
GRANVILLE SOLVENTS SITE SOURCE AREA
GRANVILLE, OHIO

ALTERNATIVE	**NCP EVALUATION CRITERIA**		
	EFFECTIVENESS	**IMPLEMENTABILITY**	**ESTIMATED COSTS**
2. **Remove Soil with Total VOCs >5,000 µg/kg by Excavation and Off-Site Disposal** Description • Remove soils with total VOCs >5,000 µg/kg • Enhanced groundwater removal with the addition of GSS-EW3[1] • Low rate pumping of 40 gpm for 5 years • Groundwater monitoring at current level for 5 years, reduced level for 10 years	<u>*Overall Protection of Human Health and the Environment*</u>: • Soil excavation and disposal of soils exceeding 5,000 µg/kg total VOCs will provide a high degree of overall protection of human health and the environment. Soil excavation and disposal would reduce the quantity of soil contaminants migrating into the Site groundwater; permanently remove soil contaminants from the Site soil; comply with ARARs by satisfying the AOC requirements; and be protective of the community, Site workers, and the environment during implementation through the implementation of effective Site control measures. • Enhanced extraction and treatment of the Site groundwater at a high flow rate (about 300 gpm) would be required over an estimated 5-year period and maintenance pumping at a low flow rate (about 40 gpm) would continue an additional 5 years[1]. <u>*Compliance with ARARs and Other Criteria, Advisories, and Guidance*</u>: • Soil excavation and disposal is a proven technology and would remove and dispose approximately 8,000 cubic yards of soils containing contaminants at levels above 5,000 µg/kg total VOCs. • Soil excavation and disposal combined with continued extraction and treatment of the Site groundwater complies with the AOC requirements that soils be treated ... "to levels which assure, to the maximum extent practicable, that no groundwater beneath the soils becomes contaminated above groundwater no further action levels." <u>*Long-Term Effectiveness and Permanence*</u>: • Soil excavation and disposal of soils exceeding 5,000 µ/kg total VOCs will be effective in reducing the migration of soil contaminants into the Site groundwater. • Natural leaching and degradation of contaminants in the soils outside of this area will reduce soil contaminant levels. These contaminants will be removed through continued operation of the groundwater treatment system. <u>*Reduction of Toxicity, Mobility, and Volume Through Treatment*</u>: • Soil excavation and disposal would remove all soils containing volatile organic contaminants at concentrations above 5,000 µg/kg. • Soil excavation and disposal would reduce the toxicity, mobility, and volume of the volatile organic contaminants in the Site soils (by their removal). • Soil excavation and disposal from the Site represents an irreversible process for the Site, but transport and disposal at a regulated, permitted hazardous waste landfill overall reduces toxicity and mobility but not volume. • Residual soil contaminants would degrade or leach into the groundwater and be captured by the groundwater treatment system. This will result in the elimination of soil contaminant toxicity, mobility, and volume through treatment. <u>*Short-Term Effectiveness*</u>: • Risk to the nearby residents resulting from the soil removal and disposal would be minimized by the implementation of effective Site controls. • Impacts to Site workers during implementation of this remedial action would be minimized by ensuring that proper personal protective equipment is provided and used. • The implementation of this alternative is not expected to impose any measurable environmental impacts. • The soil excavation and disposal alternative could be effectively implemented within 6 to 9 months of on-Site activity. • The treatment of residual soil contaminants not removed would occur through continued operation of the groundwater treatment system. The estimated time to reduce residual soil contaminant concentrations to levels which are protective of groundwater is 10 years.	<u>*Technical Feasibility*</u>: • Soil excavation and removal is a technically feasible but impractical, inasmuch as nonconventional construction techniques would be utilized for its implementation. All proposed groundwater extraction and treatment technologies have been demonstrated as technically feasible. <u>*Administrative Feasibility*</u>: • The implementation of this alternative is considered administratively feasible. But Site controls to prevent off-Site dispersion of airborne contaminants would be needed. <u>*Availability of Services and Materials*</u>: • Conventional construction equipment and adequate disposal Sites, along with the personnel required to operate it, are readily available. • There are no foreseen problems associated with obtaining the services, materials, equipment, and disposal Sites necessary to implement this alternative. <u>*State Acceptance*</u>: • State acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment. <u>*Community Acceptance*</u>: • Community acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment. Truck traffic to and from the Site could be a community consideration.	<u>Direct Capital Cost</u>: Soil - $4,529,735 Groundwater - $75,900 <u>Indirect Capital Cost</u>: Soil - $450,000 Groundwater - $13,543 <u>Annual O&M Cost</u>: Soil - None Groundwater - $70,000 (years 0-5) $31,000 (years 6-10) <u>O&M Net Present Worth Cost</u>: • Enhanced groundwater pumping - $497,666 • Groundwater monitoring - $977,487 <u>Total Net Present Worth</u>: $6,464,898

[1] Based on groundwater modeling results.

ALTERNATIVE	NCP EVALUATION CRITERIA		
	EFFECTIVENESS	IMPLEMENTABILITY	ESTIMATED COSTS
3. **Treat Soils with Total VOCs >5,000 µg/kg by *In-Situ* Mixing/Hot Gas Vaporization** Description • Treat soils with total VOCs >5,000 µg/kg with *in-situ* mixing/hot gas vaporization • Enhanced groundwater removal with the addition of GSS-EW3[1] • High rate pumping of 300 gpm for 5 years • Low rate pumping of 40 gpm for 5 years • Groundwater monitoring at current level for 5 years, reduced level for 10 years	<u>Overall Protection of Human Health and the Environment</u>: • The soil mixing alternative will provide a high degree of overall protection of human health and the environment. *In-situ* mixing/vaporization treatment of soils exceeding 5,000 µg/kg should effectively reduce the migration of soil contaminants into the Site groundwater; permanently remove soil contaminants from the Site soil; comply with ARARs by satisfying the AOC requirements; and be protective of the community, Site workers, and the environment during implementation through the implementation of effective Site control measures. • Continued extraction and treatment of the Site groundwater at a high flow (about 300 gpm) would be required over an estimated 5 year period and maintenance pumping at a low flow rate (about 40 gpm) would continue an additional 5 years. <u>Compliance with ARARs and Other Criteria, Advisories, and Guidance</u>: • *In-situ* mixing/vaporization is a proven technology and is expected to reduce contaminant concentrations below established soil cleanup levels of 5,000 µg/kg. • This treatment technology and the continued extraction and treatment of Site groundwater are expected to comply with the AOC requirement that soils be treated "...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels." <u>Long-Term Effectiveness and Permanence</u>: • The *in-situ* mixing/vaporization technology is expected to be effective in eliminating the migration of soil contaminants into the Site groundwater. • Natural leaching and degradation of remaining contaminants in the soils will reduce soil contaminant levels. These contaminants will be removed through continued operation of the groundwater treatment system. <u>Reduction of Toxicity, Mobility, and Volume Through Treatment</u>: • The *in-situ* mixing/vaporization technology is expected to remove at least 90 percent of the volatile organic contaminants in soils that are treated. • *In-situ* mixing/vaporization will reduce the toxicity, mobility, and volume of the volatile organic contaminants in the Site soils and satisfy statutory preferences for treatment. • *In-situ* mixing/vaporization is an irreversible treatment process. • Residual soil contaminants would degrade or leach into the groundwater and be captured by the groundwater treatment system. This will result in the elimination of soil contaminant toxicity, mobility, and volume through treatment. <u>Short-Term Effectiveness</u>: • Risk to the nearby residents resulting from the *in-situ* treatment of the Site soils with this alternative would not be measurable. The design of the *in-situ* mixing/vaporization treatment process will incorporate collection and treatment of the off-gases to control airborne organic compounds. • Impacts to Site workers during implementation of this remedial action would be minimized by ensuring that proper personal protective equipment is provided and used. • The implementation of this alternative is not expected to impose any measurable environmental impacts. • The estimated time to implement treatment of the soils and reduce soil concentrations below the established soil cleanup levels is less than three months. • The treatment of residual soil contaminants not removed would occur through continued operation of the groundwater treatment system. The estimated time to reduce residual soil contaminant concentrations to levels which are protective of groundwater is 10 years.	<u>Technical Feasibility</u>: • The *in-situ* soil mixing/hot gas vaporization technology is considered a technically feasible and reliable remedial option for the Site soil contaminants. All proposed groundwater extraction and treatment technologies have been demonstrated as technically feasible. • The large cranes and mixing equipment required to implement this technology may have difficulty in accessing and moving around the project Site (e.g., overhead utilities, sloped topography, and the small size of the Site. <u>Administrative Feasibility</u>: • The implementation of this alternative is considered administratively feasible. The off-gas treatment for the *in-situ* mixing technology will require an air permit-to-install or an exemption. <u>Availability of Services and Materials</u>: • The *in-situ* mixing/vaporization technology, along with personnel required for implementation, is readily available. • The services and materials necessary to implement this alternative are readily available. <u>State Acceptance</u>: • State acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment. <u>Community Acceptance</u>: • Community acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment. • The large cranes and mixing equipment needed to treat the soils with the *in-situ* mixing technology could be a community consideration.	<u>Direct Capital Cost</u>: Soil - $1,454,478 Groundwater - $75,900 <u>Indirect Capital Cost</u>: Soil - $167,771 Groundwater - $13,543 <u>Annual O&M Cost</u>: Soil - None Groundwater - $70,000 (years 0-5) $31,000 (years 6-10) <u>O&M Net Present Worth Cost</u>: • Enhanced groundwater pumping - $497,666 • Groundwater monitoring - $977,497 <u>Total Net Present Worth</u>: $3,097,512

[1] Based on groundwater modeling results

TABLE 4-4
REMEDIAL ALTERNATIVE EVALUATION SUMMARY
GRANVILLE SOLVENTS SITE SOURCE AREA
GRANVILLE, OHIO

	NCP EVALUATION CRITERIA		
ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	ESTIMATED COSTS
4. **Treat Soils with Total VOCs >5,000 µg/kg by Pneumatic Fracturing and Soil Vapor Extraction** Description • Treat soils with total VOCs >5,000 µg/kg with pneumatic fracturing and SVE • Enhanced groundwater extraction with the installation of GSS-EW3[1] • High rate pumping of 300 gpm for 5 years • Low rate pumping of 40 gpm for 5 years • Groundwater monitoring at the current level for 5 years, reduced level for 10 years	<u>*Overall Protection of Human Health and the Environment*</u>: • Successful pneumatic fracturing and SVE treatment of soils with total VOCs >5,000 µg/kg would provide a high degree of overall protection of human health and the environment. Pneumatic fracturing and SVE treatment could effectively reduce the migration of soil contaminants into the Site groundwater; permanently remove contaminants from the soil (within an estimated 5-year time period); comply with ARARs by satisfying the AOC requirements; and be protective of the community, Site workers, and the environment during implementation. • Enhanced extraction and treatment of the Site groundwater at a high flow (about 300 gpm) would be required over an estimated 5-year period and maintenance pumping at a low flow rate (about 40 gpm) would continue an additional 5 years[1]. <u>*Compliance with ARARs and Other Criteria, Advisories, and Guidance*</u>: • SVE treatment is a proven technology and should reduce contaminant concentrations below established cleanup levels. • Successful application of pneumatic fracturing and SVE treatment and continued extraction and treatment of Site groundwater are expected to comply with AOC requirement that soils be treated "...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels." <u>*Long-Term Effectiveness and Permanence*</u>: • Successful application of pneumatic fracturing and the SVE treatment would be effective in eliminating the migration of soil contaminants into the groundwater (within an estimated 5-year time period). • Natural leaching and degradation of contaminants in the soils will reduce soil contaminant levels. These contaminants will be removed through continued operation of the groundwater treatment system. <u>*Reduction of Toxicity, Mobility, and Volume Through Treatment*</u>: • Successful pneumatic fracturing and SVE treatment would be expected to remove 90% of the volatile organic contaminants in the soils that are treated. • Successful pneumatic fracturing and SVE treatment would reduce the toxicity, mobility, and volume of the volatile organic contaminants in the soils and satisfy statutory preferences for treatment. • SVE is an irreversible treatment process. • Residual soil contaminants would degrade or leach into the groundwater and be captured by the groundwater treatment system. This will result in the elimination of soil contaminant toxicity, mobility, and volume through treatment. <u>*Short-Term Effectiveness*</u>: • Risk to the nearby residents resulting from the operation of the SVE treatment system would not be measurable. If necessary, controlled air emissions from the SVE treatment system could be incorporated into the system design. • Impacts to Site workers during implementation of this remedial action would be minimized by ensuring that proper personal protective equipment is provided and used. • The implementation of this alternative is not expected to impose any measurable environmental impacts. • The estimated time to reduce soil contaminant concentrations below the established cleanup levels with successful pneumatic fracturing and SVE treatment is less than 5 years. • The treatment of residual soil contaminants not removed would occur through continued operation of the groundwater treatment system. The estimated time to reduce residual soil contaminant concentrations to levels which are protective of groundwater is 10 years.	<u>*Technical Feasibility*</u>: • The SVE technology, with enhancements to the technology using pneumatic fracturing to improve soil permeability, should be technically feasible for the Site soil contaminants. A final judgement on technical feasibility will be made after a pilot-application of the technology has been performed at the Site. All proposed groundwater extraction and treatment technologies have been demonstrated as technically feasible. <u>*Administrative Feasibility*</u>: • The implementation of this alternative is considered administratively feasible. Dependent upon the concentration of volatile organic compounds in the vapor extraction system off-gas, an air permit-to-install or an exemption may be necessary for the SVE system. <u>*Availability of Services and Materials*</u>: • The SVE and pneumatic fracturing technologies, along with the personnel required to implement them, are readily available. • The services and materials necessary to implement this alternative are readily available. <u>*State Acceptance*</u>: • State acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment. <u>*Community Acceptance*</u>: • Community acceptance of this alternative is considered likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment.	<u>Direct Capital Cost</u>: Soil - $306,728 Groundwater - $75,900 <u>Indirect Capital Cost</u>: Soil - $119,062 Groundwater - $13,543 <u>Annual O&M Cost</u>: Soil - $128,340 Groundwater - $70,000 (years 0-5) $31,000 (years 6-10) <u>O&M Net Present Worth Cost</u>: • Enhanced groundwater pumping - $497,666 • Groundwater monitoring - $977,487 <u>Total Net Present Worth</u>:[1] $2,456,598

[1] Based on groundwater modeling results

ALTERNATIVE	NCP EVALUATION CRITERIA		
	EFFECTIVENESS	IMPLEMENTABILITY	ESTIMATED COSTS
5. **Treat Soils with Total VOCs >5,000 µg/kg by *In-Situ* Thermal Treatment (Shell Process)** Description • Treat soils with total VOCs >5,000 µg/kg by *in-situ* thermal treatment • Enhanced groundwater extraction with the installation of GSS-EW3[1] • High rate pumping of 300 gpm for 5 years • Low rate pumping of 40 gpm for 5 years • Groundwater monitoring at the current level for 5 years; reduced level for 10 years	Overall Protection of Human Health and the Environment: • Thermally-enhanced soil vapor extraction of soils with total VOCs >5,000 µg/kg would provide a high degree of overall protection of human health and the environment. Thermally-enhanced soil vapor extraction would effectively reduce the migration of soil contaminants into the Site groundwater; permanently remove contaminants from the soil; comply with ARARs by satisfying the AOC requirements; and be protective of the community, Site workers, and the environment during implementation. • Enhanced extraction and treatment of the Site groundwater at a high flow (about 300 gpm) would be required over an estimated 5-year period and maintenance pumping at a low flow rate (about 40 gpm) would continue an additional 5 years.[1] Compliance with ARARs and Other Criteria, Advisories, and Guidance: • Thermally-enhanced soil vapor extraction is an innovative technology that has been developed for the treatment of VOCs in clay soils and is expected to reduce contaminant concentrations below established cleanup levels. • Successful application of the thermally-enhanced soil vapor extraction treatment process and continued extraction and treatment of Site groundwater are expected to comply with AOC requirement that soils be treated "...to levels which will assure, to the maximum extent practicable, that no groundwater beneath the soils will become contaminated above the groundwater no further action levels." Long-Term Effectiveness and Permanence: • Successful application of the thermally-enhanced soil vapor extraction treatment process is expected to be effective in eliminating the migration of soil contaminants into the groundwater. • Natural leaching and degradation of contaminants not removed will reduce soil contaminant levels. These contaminants will be removed through continued operation of the groundwater treatment system. Reduction of Toxicity, Mobility, and Volume Through Treatment: • Successful treatment by thermally-enhanced soil vapor extraction would almost quantitatively remove the volatile organic contaminants in the soils that are treated. • Successful treatment by thermally-enhanced soil vapor extraction will reduce the toxicity, mobility, and volume of the volatile organic contaminants in the soils and satisfy statutory preferences for treatment. • Thermally-enhanced soil vapor extraction is an irreversible treatment process. • Residual soil contaminants would degrade or leach into the groundwater and be captured by the groundwater treatment system. This will result in the elimination of soil contaminant toxicity, mobility, and volume through treatment. Short-Term Effectiveness: • Risk to the nearby residents resulting from the operation of the thermally-enhanced soil vapor extraction system would not be measurable. All emissions from the thermally-enhanced soil vapor extraction system will be collected and treated in an on-Site system to destroy any residual contaminants not destroyed *in-situ*. • Impacts to Site workers during implementation of this remedial action would be minimized by ensuring that proper personal protective equipment is provided and used. • The implementation of this alternative is not expected to impose any measurable environmental impacts. • The estimated time to reduce soil contaminant concentrations to below the established soil cleanup levels with thermally-enhanced soil vapor extraction, including Site preparation is 5 months. • The treatment of residual soil contaminants would occur through continued operation of the groundwater treatment system. The estimated time to reduce residual soil contaminant concentrations to levels which are protective of groundwater is 10 years.	Technical Feasibility: • The thermally-enhanced soil vapor extraction process should be a technically feasible and reliable remedial option for the Site soil contaminants. The first full-scale application of this technology is currently being conducted at a project Site in Indiana. Further judgement on technical feasibility will be made once the results of the first full-scale application of this technology are available. All proposed groundwater extraction and treatment technologies have been demonstrated as technically feasible. Administrative Feasibility: • The implementation of this alternative is considered administratively feasible. An air permit-to-install may be required for the discharge stack of the emissions control system of the thermally-enhanced soil vapor extraction system. Availability of Services and Materials: • The equipment and personnel required to implement the thermally-enhanced soil vapor extraction system should be available within a reasonable time frame. • If the thermally-enhanced soil vapor extraction process is demonstrated to be successful during the first full-scale application, problems associated with obtaining the services and materials necessary to implement this alternative are not anticipated. State Acceptance: • State acceptance of this alternative would be likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment. Community Acceptance: • Community acceptance of this alternative would be likely based on its anticipated effectiveness, compliance with ARARs, and anticipated overall protection of human health and the environment.	Direct Capital Cost: Soil - $1,500,000 to $2,000,000 Groundwater - $75,900 Indirect Capital Cost: Soil - $140,000 to $180,000 Groundwater - $13,543 Annual O&M Cost: Soil - None Groundwater - $70,000 (years 0-5) $31,000 (years 6-10) O&M Net Present Worth Cost: • Enhanced groundwater pumping - $497,666 • Groundwater monitoring - $977,497 Total Net Present Worth: $3,115,1634 to $3,655,163

[1] Based on groundwater modeling results

TABLE 4-6
COMPARISON OF COSTS FOR ALTERNATIVES 1 THROUGH 5

Alternative Number	Soil Remedy	Soil Remedy Estimated Direct Capital Cost	Soil Remedy Estimated Indirect Capital Cost	Soil Remedy Estimated Annual O&M Cost	Soil Remedy Estimated Net Present Worth Cost	Groundwater Remedy	Groundwater Remedy Estimated Direct Capital Cost	Groundwater Remedy Estimated Indirect Capital Cost	Groundwater Remedy Estimated Annual O&M Cost	Groundwater Remedy Estimated Net Present Worth Cost	Groundwater Monitoring Scenario	Estimated Net Present Worth Cost of Groundwater Monitoring	TOTAL NET PRESENT WORTH COST
1	No Action	None	None	None	None	Existing system	None	None	$70,000 (years 0-3); $31,000 (years 4-20)	$638,394	Monitor for 16 years at current level and 15 years at reduced level	$1,761,833	$2,400,267
2	Soil Removal by Excavation and Disposal	$4,529,735	$460,000	None	$4,989,735	Install EW-3 as new extraction well and operate EW-3 for 5 years at 300 ppm then maintenance pump from EW-3 for 5 more years at 40 gpm.	$75,900	$13,543	$70,000 (years 0-5) $31,000 (years 6-10)	$497,666	Monitor for 5 years at current level and 10 years at reduced level.	$977,497	$6,464,898
3	*In-Situ* Mixing/Hot Gas Vaporization of Soil Areas	$1,454,578	$167,771	None	$1,622,349	Install EW-3 as new extraction well and operate EW-3 for 5 years at 300 ppm then maintenance pump from EW-3 for 5 more years at 40 gpm.	$75,900	$13,543	$70,000 (years 0-5) $31,000 (years 6-10)	$497,666	Monitor for 5 years at current level and 10 years at reduced level.	$977,497	$3,097,512
	Treatment of Soils Via Pneumatic Fracturing and Soil Vapor Extraction	$306,728	$118,062	$128,340	$981,435 (based on 5 years of O&M costs)	Install EW-3 as new extraction well and operate EW-3 for 5 years at 300 ppm then maintenance pump from EW-3 for 5 more years at 40 gpm.	$75,900	$13,543	$70,000 (years 0-5) $31,000 (years 6-10)	$497,666	Monitor for 5 years at current level and 10 years at reduced level.	$977,497	$2,456,598
5	Treatment of Soils Via Thermally-Enhanced Soil Vapor Extraction (Shell Process)	$1,500,000 to $2,000,000	$140,000 to $180,000	None	$1,640,000 to $2,180,000	Install EW-3 as new extraction well and operate EW-3 for 5 years at 300 ppm then maintenance pump from EW-3 for 5 more years at 40 gpm.	$75,900	$13,543	$70,000 (years 0-5) $31,000 (years 6-10)	$497,666	Monitor for 5 years at current level and 10 years at reduced level.	$977,497	$3,115,163 to $3,655,163

5.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Based on the comparative analyses and cost analyses provided above, the recommended Removal Action for the Site soils is Alternative 4, Table 5-1. This alternative consists of two parts. Part 1 includes the installation of an additional groundwater extraction well that will more efficiently remove contaminant mass from the water table and as it leaches from the impacted site soils.

Part 2 of this action is to implement a soil vapor extraction system enhanced by pneumatically fracturing the soil (Figure 18). This system will consist of soil vapor extraction wells placed in the areas and depths at which the soil contains VOCs above 5,000 μg/kg.

TABLE 5-1
RECOMMENDED ALTERNATIVE

Pneumatic Fracturing and Soil Vapor Extraction
• Enhance groundwater extraction system.
• Pneumatically fracture soil and use soil vapor extraction over area with total VOCs concentrations that exceed 5,000 μg/kg.

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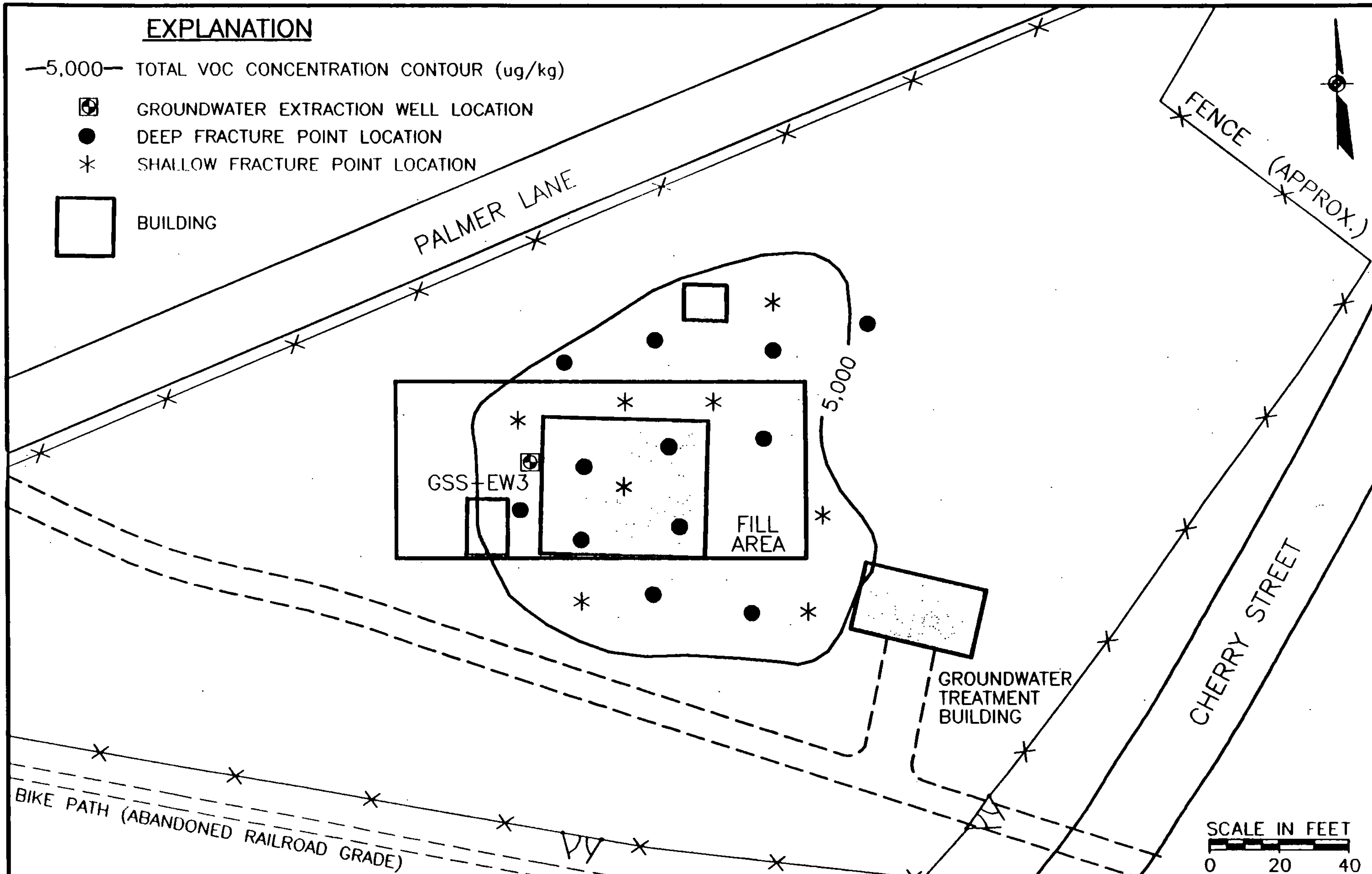

M&E Metcalf & Eddy

GRANVILLE SOLVENTS SITE
ENGINEERING EVALUATION COST ANALYSIS
PRELIMINARY SVE WELL AND GROUNDWATER EXTRACTION WELL LOCATIONS
1996
GRANVILLE, OHIO

Project Number	
016688	
File Name	Figure
EECA-10	18

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6.0 REFERENCES

Baker, L.W., MacKay, K.P. 1985. "Screening Models for Estimating Toxic Air Pollution Near a Hazardous Waste Landfill". J. Air Pollution Control Assoc. 35: 1190-1195.

Clean Harbors of Kingston, Inc. for Ohio EPA. 1990(?). Final Report Granville Solvents, Inc..

Compliance Solutions, Inc. for U.S. EPA. 1992. Granville Solvents Interim Action.

Compliance Solutions, Inc. for U.S. EPA. 1993. Granville Solvents Interim Action.

Gifford, F.A., Hanna, S.R. 1970. "Urban Air Pollution Modeling". Proceedings of the Second International Clean Air Congress. H.M. Englund, W.T. Beery, eds., Academic Press, NY.

Metcalf & Eddy, Inc. 1995. Aquifer Pumping Test Report for the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.

Metcalf & Eddy, Inc. 1995. Design Technical Memorandum for the Remediation of Impacted Soils at the Granville Solvents Site in Granville, Ohio; for the Granville Solvents PRP Group.

Metcalf & Eddy, Inc. 1995. Groundwater Monitoring Program Plan for the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.

Metcalf & Eddy, Inc. 1995. Work Plan for the Removal Action at the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.

Metcalf & Eddy, Inc. 1996. Groundwater Contaminant Fate and Transport Modeling Report; for the Granville Solvents Site PRP Group.

Metcalf & Eddy, Inc. 1996. Monitoring Well Installation Report for the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.

Metcalf & Eddy, Inc. 1996. Quality Assurance Project Plan for the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.

Metcalf & Eddy, Inc. 1996. Soil Data Report for the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.

Metcalf & Eddy, Inc. 1996. Addendum 1 - Soil Data Report for the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.

Metcalf & Eddy, Inc. 1996. Addendum 1 - Monitoring Well Installation Report for the Granville Solvents Site in Granville, Ohio; for the Granville Solvents Site PRP Group.

PRC Environmental Management, Inc. for U.S. EPA. 1993. Screening Site Inspection Site Evaluation - Granville Solvents, Inc.

Tennekes, H. 1976. "Observations on the Dynamics and Statistics of Simple Box Models with a Variable Inversion Lid". Third Symposium on Atmospheric Turbulence, Diffusion and Air Quality, American Meteorological Society, Boston, MA, pp 397-402.

U.S. EPA. 1988. U.S. Environmental Protection Agency. Office of Remedial Response. Superfund Exposure Assessment Manual. Washington DC: U.S. Environmental Protection Agency, EPA/540/1-88/001.

U.S. EPA. 1989. U.S. Environmental Protection Agency. Hazardous Waste Treatment, Storage and Disposal Facilities (TSDF) - Air Emission Models. Office of Air and Radiation. Research Triangle Park, NC. EPA/200/004

U.S. EPA. 1991e. U.S. Environmental Protection Agency. Role of Baseline Risk Assessment in Superfund Remedy Selection Decisions. Office of Solid Waste and Emergency Response. Washington, DC, OSWER Directive 9355.0-30, April 22, 1991.

U.S. EPA. 1994. Administrative Order by Consent Pursuant to Section 106 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as Amended, 42 U.S.C.S. 9606(a) in the Matter of Granville Solvents Site; September 7, 1994.

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